



IMPERIAL INSTITUTE
OF
AGRICULTURAL RESEARCH, PUSA.

TRANSACTIONS AND PROCEEDINGS
OF THE
BOTANICAL SOCIETY OF EDINBURGH.

TRANSACTIONS AND PROCEEDINGS
OF THE
BOTANICAL SOCIETY OF EDINBURGH

VOLUME XXX.

INCLUDING SESSIONS XCII-XCV.
(1927-1931.)

WITH 21 PLATES AND OTHER ILLUSTRATIONS.



EDINBURGH :
PRINTED FOR THE BOTANICAL SOCIETY.

1931.

CONTENTS OF VOL. XXX.

	PAGE
Proceedings for Session 1927-1928	i
Do. do. 1928-1929	ix
Do. do. 1929-1930	xvii
Do. do. 1930-1931	xxv
Notes on Caithness Plants. By Arthur Bennett, A.L.S.	1
Notes on the Effect of Cutting Bracken (<i>Pteris aquilina</i> L.). By William G. Smith, B.Sc., Ph.D.	3
A Seed-borne Disease of Clover (<i>Trifolium repens</i> L.). By N. L. Alcock, F.L.S. (Plate I)	13
Injection Experiments on Trees. By R. J. D. Graham and L. B. Stewart	19
On the Occurrence of Schizocotyly in certain Ranunculaceous Seedlings. By Elizabeth W. Miller, B.Sc.	21
Light Receptors in <i>Mesembryanthemum</i> . By Chrissy I. Kean, B.Sc.	37
Artificial Crystals in Preserved Tissue of <i>Mesembryanthemum</i> . By Chrissy I. Kean, B.Sc. (Plate II)	43
Note on a Circumnutation Record. By Marjorie L. R. Bovell, B.Sc.	46
The Scottish Alpine Botanical Club Excursion, 1927. By Rev. J. J. Marshall Lang Aiken, B.D.	49
The Reaction of the Medium in Relation to Root Formation in Coleus. By E. Philip Smith, B.A., Ph.D., F.L.S.	53
The Causal Parasite of the Lily Disease. By James Wright, B.Sc.	59
Vegetative Propagation: Leaf Cuttings in Gymnosperms. By R. J. D. Graham and L. B. Stewart. (Plate III)	67
Vegetative Propagation: <i>Kalanchoe verticillata</i> . By C. M. Baron, R. J. D. Graham, and L. B. Stewart	70
Physical Changes brought about by the Floating Power of Seaweed. By Symington Grieve. No.1. (Plate IV)	72
Physical Changes brought about by the Floating Power of Seaweed. By Symington Grieve. No. 2. (Plates V-IX)	78
Physical Changes brought about by the Floating Power of Seaweed. By Symington Grieve. No. 3. (Plate X)	89
The Structure of certain Poricidal Anthers. By J. R. Matthews and C. M. MacLachlan	104

	PAGE
Notes on the Introduction and Distribution of the Ivy-leaved Toad-Flax (<i>Linaria Cymbalaria</i> Mill.) in Scotland. By Hugh Boyd Watt	123
Cork Formation in Rhododendron. By C. Marion Baron	127
<i>Vaccinium intermedium</i> Ruthe on the South Pennine Moors and on Cannock Chase. By W. Balfour Gourlay, M.A. (Plate XI)	131
Preliminary Report on a Variety of Red Currant Resistant to Weymouth Pine Rust. By Glenn Gardner Hahn, B.Sc., M.Sc., Ph.D. (Plates XII-XIII)	137
Notes on Strand Plants. III. <i>Salsola Kali</i> L. By Isabella S. McNicoll, B.Sc.	147
Notes on Strand Plants. IV. <i>Arenaria peploides</i> L. By Alexander Pratt, B.Sc.	157
Seedling Anatomy in the Genus <i>Mesembryanthemum</i> . By Chrissy I. Kean, B.Sc.	164
Obituary Notices—	
William Gardner Smith	175
Robert Cockburn Millar	178
Arthur Bennett	180
David Paul	183
Glen Affric. By Robert Moyes Adam. (Plate XIV)	187
A List of Scottish Pansies. By Eric Drabble, D.Sc., F.L.S.	190
Leaf Anatomy of the British Heaths. By Margaret H. Smith, B.Sc.	198
The Recognition of some Agricultural Grasses by their Vegetative Characters. By J. H. Whyte, B.Sc.	206
The Spread of Bracken by Spores. By J. H. Whyte, B.Sc.	209
Experiments with Vita Glass. By R. J. D. Graham and L. B. Stewart	212
Vegetative Propagation of Broccoli from Heads. By R. J. D. Graham and L. B. Stewart. (Plate XV)	216
Development and Anatomy of Monocotylous Seedlings. 1. <i>Paris polyphylla</i> ; 2. <i>Costus speciosus</i> . By Lucy Boyd, B.Sc.	218
Flower Colours as Natural Indicators. By Edith Philip Smith, B.A., Ph.D.	230
Notes on Galloway Roses. By J. R. Matthews, M.A.	239
A Note on a Rare Parasitic Fungus on <i>Myrica Gale</i> L.— <i>Ovularia destructiva</i> (Phil. et Plow.) Massec. By C. E. Foister, B.A.	244
The Scottish Alpine Botanical Club Excursion, 1928. By Robert Moyes Adam. (Plate XVI)	246
The Scottish Alpine Botanical Club Excursion, 1929. By Robert Moyes Adam. (Plate XVII)	250
The White Tip Disease of Leeks and its Causal Fungus, <i>Phytophthora Porri</i> n. sp. By C. E. Foister, B.A., Ph.D. (Plate XVIII)	257

	PAGE
Studies in Vegetative Propagation: <i>Acalypha</i> , <i>Dioscorea</i> , and <i>Stenoglottis longifolia</i> . By R. J. D. Graham and L. B. Stewart. (Plate XIX)	282
Anomalous Stem Structure in <i>Ruscus aculeatus</i> Linn. By Hamish Boyd Gilliland	284
Evolution in the Monocotyledonous Seedling: A New Interpretation of the Morphology of the Grass Embryo. By Lucy Boyd, D.Sc.	286
Notes on Salt-Marsh Plants. I. <i>Glauz maritima</i> Linn. By Margaret A. Moir, B.Sc.	304
Notes on Salt-Marsh Plants. II. <i>Plantago maritima</i> Linn. By David F. Stewart, B.Sc.	313
Notes on Salt-Marsh Plants. III. <i>Triglochin maritimum</i> Linn. By James Park, B.Sc.	320
The Scottish Alpine Botanical Club Excursion, 1930. By Robert Moyes Adam. (Plates XX-XXI)	326
Notes on Common Diseases sometimes Seed-borne. By N. L. Alcock, F.L.S.	332
List of Fungous Diseases received by the Pathological Department of the Department of Agriculture for Scotland. By N. L. Alcock, F.L.S., and C. E. Foister, B.A., Ph.D.	338
Obituary Notice— William Carmichael M'Intosh	351
APPENDIX—Roll of the Botanical Society of Edinburgh	353
List of Exchanges	359
INDEX	364

4986



IARI

Botanical Society of Edinburgh.

(FOUNDED 1836.)

OCTOBER 1928.



I.—GENERAL VIEWS AND OBJECTS OF THE SOCIETY.

THE attention of the Society is turned to the whole range of Botanical Science, together with such parts of other branches of Natural History as are more immediately connected with it. These objects are cultivated :—

1. By holding Meetings for the interchange of botanical information, for the reading of original papers or translations, abstracts or reviews of botanical works, regarding any branch of botanical knowledge, practical, physiological, geographical, and palæontological,—and the application of such knowledge to Agriculture and the Arts.

2. By publishing *Proceedings and Transactions*, including a List of Members.

3. By the formation in Edinburgh of an Herbarium of Foreign and British Plants, and of a Library and Museum for general consultation and reference.

4. By printing from time to time Catalogues of Plants, with the view of facilitating the study of their geographical distribution, and furthering the principle of exchange.

5. By making Botanical Excursions both in the neighbourhood of Edinburgh and to distant parts of Britain.

II.—LAWS OF THE SOCIETY.

CHAPTER I.

FUNDAMENTAL LAWS.

1. The Society shall be denominated "THE BOTANICAL SOCIETY OF EDINBURGH."

2. The object of the Society shall be the advancement of Botanical Science, by means of periodical meetings, publications, correspondence, and interchange of specimens amongst its Members.

3. The Society shall be open to Ladies and Gentlemen, and shall consist of Honorary and Ordinary Fellows, and Corresponding Members, who shall have the privilege of denominating themselves Fellows of the Society; of Associates elected under the rule Chapter IV., Section 4 hereof, and of Lady Members elected under the rule Chapter IV., Section 5 hereof, and of Ordinary Members elected under the rule Chapter IV., Section 6 hereof.

CHAPTER II.

ORDINARY MEETINGS.

1. A Meeting of the Society shall be held on the Third Thursday of every month, from October to June inclusively.

2. Intimation of all papers to be brought before the Society must be given to the Secretary and submitted to the Council ten days at least previous to the Meeting at which they are to be read.

3. Any Member may transmit to the Society Papers and Communications, which, if approved of by the Council, may be read by the author, or, in his absence, by the President or Secretary, at any of the Ordinary Meetings.

4. The following order of business shall be observed :—

PRIVATE BUSINESS.

1. Chair taken.

2. Minutes of Private Business of preceding Meeting read.

3. Report of Council read.

4. Applications for Admission read.

5. Members proposed at preceding Meeting balloted for.

6. Motions intimated at previous Meetings discussed.

7. New Motions intimated.
8. Miscellaneous Business.
9. Society adjourned.

PUBLIC BUSINESS.

1. Chair taken.
 2. Laws signed by New Members.
 3. Minutes of Public Business of preceding Meeting read.
 4. Papers and Communications for next Meeting announced.
 5. Specimens, Books, etc., presented.
 6. Communications and Papers read.
 7. Society adjourned.
-

CHAPTER III.

EXTRAORDINARY MEETINGS.

An Extraordinary Meeting of the Society may be called at any time, by authority of the Council, on the requisition of three or more Fellows.

CHAPTER IV.

ADMISSION OF MEMBERS.

SECTION I.—HONORARY FELLOWS.

1. The Honorary Fellows shall be limited to six British and twenty-five Foreign,—by British, being understood British subjects, whether resident in the British Islands or not.

2. The Council shall have the privilege of proposing Honorary Fellows,—the names of the gentlemen proposed being always stated in the Billet calling the Meeting at which they are to be balloted for. The election to be determined by a majority of at least two-thirds of the votes, provided fifteen Fellows are present and vote.

3. Any Fellow may submit to the Council the names of individuals whom he would wish proposed as Honorary Fellows; and should the Council decline to bring these forward, he may demand that they be balloted for.

4. Honorary Fellows shall be entitled to all the privileges of Ordinary Fellows, and shall receive copies of the *Transactions* free of charge.

SECTION II.—ORDINARY FELLOWS.

1. A candidate for admission into the Society, as an Ordinary Fellow, must present an application, with a recommendation annexed, signed by at least two Fellows. The application shall be read at the proper time during private business, and at the next Ordinary Meeting shall be determined by a majority of at least two-thirds of the votes, provided fifteen Fellows are present and vote.

2. Ordinary Fellows shall, on admission, sign the Laws, and pay the sum of Fifteen Shillings to the funds of the Society; and shall contribute Fifteen Shillings annually thereafter at the October Meeting. Ordinary Fellows are entitled to receive the *Transactions*, provided their subscriptions are paid.

3. Ordinary Fellows may at any time compound for their annual contributions by payment of Ten Guineas. They shall be entitled to receive the *Transactions* yearly as published.

4. Fellows who are not in arrear in their subscriptions, and in their payments for the *Transactions*, will receive copies of the latter, provided they apply for them within two years after publication. Fellows not resident in Edinburgh must apply for their copies, either personally or by an authorised agent, to the Secretary or Treasurer.

5. The Society shall from time to time adopt such measures regarding Fellows in arrears as shall be deemed necessary.

SECTION III.—CORRESPONDING MEMBERS.

Any person residing abroad may be balloted for as a Corresponding Member, on the recommendation of the Council.

SECTION IV.—ASSOCIATES.

The Society shall have power to elect by ballot, on the recommendation of the Council, Associates from those who may have acquired a claim on the Society by transmitting specimens or botanical communications. Associates have no vote in elections or in the transaction of the business of the Society, are not entitled to receive copies of the *Transactions*, and have no interest in the property of the Society.

SECTION V.—LADY MEMBERS.

Any Lady may become, on the recommendation of the Council, a Member for life on payment of a single contribution of Two Guineas, or may be elected and continue a Member on payment annually of a subscription of Ten Shillings; but Lady Members elected under this rule shall not be entitled to receive copies of the *Transactions*, shall have no voice in the management of the Society, nor any interest in the property thereof.

SECTION VI.—ORDINARY MEMBERS.

The Society shall have power to elect, on the recommendation of the Council, Ordinary Members, being ladies or gentlemen who, though not desiring to become Fellows, are interested in the objects of the Society. The name of any candidate proposed as an Ordinary Member shall be submitted to the Council on a formal application, signed by two Ordinary Fellows, to one of whom at least the candidate must be personally known, and, if approved, the election of such candidate will take place at next Ordinary Meeting. Ordinary Members shall have no vote in elections or in the transaction of the business of the Society, and they shall have no interest in its property. They shall pay the sum of Five Shillings on admission, and shall contribute Five Shillings annually thereafter, at the October meeting. They may also receive copies of the *Transactions* published subsequent to their admission, at prices to be fixed from time to time by the Council of the Society.

SECTION VII.—BALLOTING.

In the foregoing sections which relate to admission of members to the Society, the Council shall have power to recommend admission without ballot, unless such ballot is demanded by giving written notice to the Honorary Secretary two days before the date of proposed election. Any such ballot will be taken at the next Ordinary Meeting of the Society.

 CHAPTER V.

OFFICE-BEARERS.

1. The Office-Bearers of the Society may be chosen from the Ordinary Fellows, and they shall consist of a President, four Vice-

Presidents, ten Councillors, an Honorary Secretary, an Assistant Secretary, a Foreign Secretary, and a Treasurer, who shall be elected annually at the Ordinary Meeting in October.

2. The Council shall annually prepare a list of Fellows whom they propose to nominate as Office-Bearers for the ensuing year. This list shall be printed and put into the hands of Fellows, along with the Billet of the October Meeting ; and Fellows shall vote by putting these lists into the ballot-box, with any alterations they may think proper to make. The lists shall not be signed. Every Fellow present at the Meeting is entitled to vote.

3. All the Office-Bearers may be re-elected, except the two senior Vice-Presidents and the three senior Councillors, who shall not be re-eligible to the same offices till after the interval of one year.

4. These Office-Bearers shall form the Council for the general direction of the affairs of the Society. Three to be a quorum.

5. The Council shall nominate annually an Auditor and an Artist, to be recommended to the Society.

6. The Council shall appoint annually three of their number, including the Honorary Secretary, who shall have power to co-opt additional referees, if necessary, to act as editors and superintend the printing of the *Transactions*.

7. The Council may at any time be called upon by the President, Vice-Presidents, or Secretaries, to meet with them for the transaction of private business.

8. The Council shall hold a Meeting for business on the second Monday before each General Meeting.

CHAPTER VI.

THE PRESIDENT AND VICE-PRESIDENTS.

It shall be the duty of the President and Vice-Presidents when in the chair, and of the Chairman in their absence, to conduct the business of the Society according to the order of the business laid down in Chapter II., Law 4, and to attend carefully to the enforcement of the Laws of the Society, and to signing the Minutes. The Chairman shall have a vote and a casting vote.

CHAPTER VII.

THE SECRETARIES.

1. The Honorary Secretary, with the aid of the Assistant Secretary, shall give intimation of all General and Committee Meetings, shall Minute their proceedings in Books to be kept for the purpose, and shall conduct all the Society's Correspondence in Britain. He shall also take charge of all Donations of Plants and Books, and shall see them deposited in the Herbarium and Library, in conformity with any arrangements made by the Society with Government.

2. The Foreign Secretary shall have charge of all the Foreign Correspondence.

Note.—Agreeably to an Act of the Town Council of the City of Edinburgh, dated January 8, 1839, the Professor of Botany in the University of Edinburgh is constituted Honorary Curator *ex officio*, with free access to the Society's Collection, whether a Member of the Society or not.

CHAPTER VIII.

THE TREASURER AND AUDITOR.

1. The Treasurer, subject to the inspection of the Council, shall receive and disburse all money belonging to the Society, collecting the money when due, and granting the necessary Receipts. His Accounts shall be audited annually by the Auditor appointed by the Society.

2. It shall be the duty of the Treasurer to place all money belonging to the Society in one of the Chartered Banks of this City, unless the same shall have been ordered by the Society to be otherwise invested; and he shall never keep more than Ten Pounds of the Funds of the Society in his hands at a time. The Bank Account shall be kept in the name of the Society, and all drafts thereon shall be signed by the Treasurer.

3. The Treasurer shall, at the November Meeting, submit a certified Statement of the Receipts and Expenditure of the past year, with the Auditor's Report thereon.

CHAPTER IX.

VISITORS.

Each Fellow shall have the privilege of admitting one Visitor to the Ordinary Meetings of the Society at the close of the private business.

CHAPTER X.

ADDITIONAL LAW.

In the event of any Member acting in such a way as shall seem to the Fellows of the Society to be detrimental to its interests, the Council may recommend that the name of such Member be deleted from the roll. The recommendation shall be brought before the Society at its first Ordinary Meeting. It shall be finally decided at the immediately succeeding Meeting by ballot. If confirmed by a majority of two-thirds of the votes of at least fifteen Fellows, the name of such persons shall be deleted from the roll of Membership, and all his privileges connected with the Society shall be forfeited.

CHAPTER XI.

MAKING AND ALTERING LAWS.

Any motion for the alteration of existing Laws, or the enactment of new ones, shall lie over till the second Ordinary Meeting, and shall then be determined by a majority of at least two-thirds of the votes, provided fifteen Fellows are present and vote. The motion must be intimated to the Council, and shall be printed in the Billet calling the Meeting at which it is to be brought forward, and also in the Billet of the Meeting at which it is to be discussed.

PROCEEDINGS
OF THE
BOTANICAL SOCIETY OF EDINBURGH.

SESSION XCII

OCTOBER 20, 1927.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

The following Office-Bearers were elected for Session
1927-1928:—

PRESIDENT.

JOHN SUTHERLAND, C.B.E., LL.D.

VICE-PRESIDENTS.

T. CUTHBERT DAY, F.I.C.	SYMINGTON GRIEVE, Esq.
W. EDGAR EVANS, B.Sc., F.R.S.E.	J. RUTHERFORD HILL, Ph.C.

COUNCILLORS.

D. ARMSTRONG, Esq.	Miss E. PHILIP SMITH, B.A.,
E. M. BUCHANAN, Esq.	Ph.D., F.L.S.
Professor MONTAGU DRUMMOND,	W. G. SMITH, B.Sc., Ph.D.
M.A., F.L.S., F.R.S.E.	Professor W. WRIGHT SMITH, M.A.,
JAMES W. GREGOR, Ph.D.	F.L.S., F.R.S.E.
ANDREW HARLEY, Esq.	MALCOLM WILSON, D.Sc., F.L.S.,
J. M. MURRAY, B.Sc.	F.R.S.E.

Honorary Secretary—J. R. MATTHEWS, M.A., F.L.S., F.R.S.E.

Foreign Secretary—Very Rev. D. PAUL, M.A., D.D., LL.D.

Treasurer—ANDREW MASON, Esq., c/o RICHARD BROWN & Co., C.A.

Assistant-Secretary—J. T. JOHNSTONE, M.A., B.Sc.

Artist—R. M. ADAM.

Auditor—ROBERT C. MILLAR, C.A.

Mrs. MURRAY REID was elected a Resident Fellow.

Mr. GEORGE FORREST was elected an Associate.

Miss J. J. STEVENSON and Miss C. M. BARON were elected Ordinary Members.

Mr. E. M. BUCHANAN read a paper on Types of Forest and of People in Burma. He showed how the different types of forest are related to the geographical features and geological formations of the country, and illustrated his paper with a large number of lantern slides. He also gave some account of the different types of people among the inhabitants.

NOVEMBER 17, 1927.

W. EDGAR EVANS, B.Sc., F.R.S.E., Vice-President, in the Chair.

The TREASURER, Mr. ANDREW MASON, submitted the following Statement of Accounts for Session 1926-1927 :—

INCOME.		
Annual Subscriptions for 1926-1927	£45 15 0	
Do. Arrears	1 15 0	
Transfer from Life Members' Fund	21 18 10	
Transactions sold	7 7 6	
Interest on Funds Invested and in Bank	13 2 8	
Subscriptions to Publications Fund	24 2 0	
Income from Botanical Society Trust Fund	17 14 3	
	<u>£131 15 3</u>	
EXPENDITURE.		
Printing <i>Transactions</i> for Session 1925-1926	£70 15 5	
Printing and Postage of Notices for Meetings, etc. . . .	21 2 7	
Rooms for Meetings and Tea	7 3 10	
Stationery, Postages, Advertising, etc.	4 7 10	
Fire Insurance on Books, etc.	0 5 0	
Honorarium to Treasurer	3 3 0	
	<u>£106 17 8</u>	
Excess of Income over Expenditure	<u>£24 17 7</u>	
STATE OF FUNDS.		
<i>Life Members' Fund.</i>		
Balance of Fund at close of Session 1925-1926	£263 15 10	
Add—Life compositions received	36 15 0	
	<u>£300 10 10</u>	
Deduct—Transferred to Income	21 18 10	
Balance as at close of Session	<u>£278 12 0</u>	

Brought forward, £278 12 0

Ordinary Fund.

Balance of Fund at close of Session 1925—		
1926	£95 9 6	
Add—Increase during Session 1926—		
1927	24 17 7	
	<hr/>	
Balance as at close of Session, subject to expense of printing Transactions		120 7 1
		<hr/>
Total Funds	£398 19 1	
Being :—£200 5% War Stock, 1929–1947,		
at cost	£194 18 3	
Sum in Current Account with		
Union Bank of Scotland, Ltd.	5 0 10	
Sum in Deposit Receipt with do.	200 0 0	
	<hr/>	
	£399 19 1	
Less—Subscription received in advance	1 0 0	
	<hr/>	
As above	£398 19 1	

Note.—Subscriptions in arrear, considered recoverable: 1925–26, 15s.; 1926 27, £5, 10s.

EDINBURGH, 7th November 1927.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for Session 1926–1927, and have found them correct. I have also checked the foregoing Abstract, and find it correct.
ROBT. C. MILLAR, C.A., Auditor.

BOTANICAL SOCIETY TRUST FUND.

INCOME.

Interest on Funds invested	£17 14 3
--------------------------------------	----------

EXPENDITURE.

To Publications Fund	£17 14 3
--------------------------------	----------

EDINBURGH, 7th October 1927.—I have examined the books and vouchers of the Edinburgh Botanical Society Trust Fund, and certify the same to be correct.

ROBERT L. GORRIE.

MISS MARGARET GAIRNS DOBSON and Mr. J. M. S. LANG were elected Resident Fellows.

Mr. ALEX. B. BROWN, Mrs. BUYERS, Miss EVANS, Miss ELSA DRYDEN ROBERTSON, and Mr. JAMES WRIGHT were elected Ordinary Members.

Mr. R. M. ADAM read a paper on *Codium adhaerens* Ag. and other Algae from West Inverness-shire. Hitherto *Codium adhaerens* Ag. has not been reported from any Scottish locality and its discovery in Loch-nan-Uamh adds considerably to the

geographical range of the species. It has already been found in a few localities in western Ireland and the shores of southern England. The paper was illustrated with specimens and lantern slides.

Mr. ARTHUR BENNETT communicated a paper: Notes on Caithness Plants (see p. 1).

Mr. J. RUTHERFORD HILL exhibited a fine specimen of *Peloria* in Foxglove.

Specimens of *Cnicus heterophyllus* var. *laciniosus* were exhibited on behalf of Mr. ARTHUR BENNETT.

Mr. L. B. STEWART exhibited specimens of *Zamioculcas Loddigesii* showing regeneration from leaflets.

The following plants in flower were shown from the Royal Botanic Garden:—*Aphelandra aurantiaca* Lindl. var. *Roczlii*; *Callicarpa purpurea* Juss.; *Casuarina distyla* Vent.; *C. quadrivalvis* Labill.; *Clematis ranunculoides* Franch.; *Columnea gloriosa* Sprague; *Cymbidium erythrostylum* Rolfe; *C. Mastersii* Griff.; *Dendrobium Victoriae-Reginae* Loher; *Dichorisandra thyrsiflora* Mikan; *Hoheria populnea* A. Cunn.; *Masdevallia laucheana* Kraenzl.; *Pinguicula caudata* Schlecht., and *Polystachya puberula* Lindl.

DECEMBER 15, 1927.

JOHN SUTHERLAND, C.B.E., LL.D., President, in the Chair.

Mr. E. WYLLIE FENTON was elected a Resident Fellow.

Miss A. MARGARET MITCHELL was elected an Ordinary Member.

Mr. W. EDGAR EVANS moved that the following Alteration of Laws be made:—

CHAPTER IV.—ADMISSION OF MEMBERS.

That Section II., paragraph 3, be altered to read:

Resident Fellows may at any time compound for their annual contributions by payment of Ten Guineas. They shall be entitled to receive the *Transactions* yearly as published.

This was seconded by Mr. J. RUTHERFORD HILL and carried unanimously.

Mr. J. RUTHERFORD HILL moved that the following Alteration of Laws be made :—

CHAPTER IV.—ADMISSION OF MEMBERS. *

That Section III., which deals with Non-Resident Fellows, be deleted.

This was seconded by Mr. SYMINGTON GRIEVE and carried unanimously.

Miss M. J. F. WILSON read a paper on the Dutch Elm Disease, a serious disease on the Continent, and recently discovered near London. The paper was illustrated by a large number of lantern slides.

The following plants in flower were shown from the Royal Botanic Garden :—*Angraecum caespitosum* Rolfe ; *Billbergia zebrina* Lindl. ; *Cochlioda vulcanica*, Benth. ; *Coelogyne assamica* Linden et Rehb. f. ; *Cymbidium Coningsbyanum* × ; *C. elegans* Lindl. ; *C. Hanburyanum* × ; *Epidendrum ciliare* Linn. var. *giganteum* ; *Eriogonum nudum* Dougl. ; *Laelia anceps* Lindl. ; *Lilium nepalense* D. Don ; *Marillaria grandiflora* Lindl. ; *Oncidioida Charlesworthii* × ; *Oncidium cheiroporum* Rehb. f. ; *Ornithidium coccineum* Salisb., and *Platyclinis Cobbiana* Hemsl.

JANUARY 19, 1928.

JOHN SUTHERLAND, C.B.E., LL.D., President, in the Chair.

Miss MARY S. MARTIN was elected an Ordinary Fellow.

Dr. W. G. SMITH read a paper : Notes on the Effect of Cutting Bracken, and illustrated it with lantern slides and specimens (see p. 3).

Miss MARY S. MARTIN read a paper : A Note on Seed-borne Disease of Clover by Mrs. N. L. ALCOCK and herself, and illustrated it with lantern slides (see p. 13).

Miss ELSIE CADMAN exhibited cultures of *Didymium difforme* and *D. nigripes*.

The following plants in flower were shown from the Royal Botanic Garden :—*Ardisia mamillata* Hance ; *Chorizema ilicifolium* Labill. ; *Coelogyne sulphurea* Rehb. f. ; *Cymbidium*

edinensis × ; *Echeveria multicaulis* Rose ; *Eria globifera* Rolfe ; *Felicia echinata* Nees ; *Masdevallia Schroederiana* Sander ; *Odontoglossum Groganiae* × ; *O. Uroskinnei* Lindl. : *Senecio grandifolius* Less. ; *Visnea Mocanera* Linn. f., and *Xylobium scabrilingue* Rolfe.

FEBRUARY 16, 1928.

JOHN SUTHERLAND, C.B.E., LL.D., President, in the Chair.

Mrs. GEORGE FORREST, Mr. JOHN BRODIE, Mr. CHARLES D'ARCY MCGINN, Dr. JOHN LEWIS OWEN, and Mr. WILLIAM HENRY TRAILL were elected Ordinary Fellows.

GEORGE FORREST, jun., JOHN ERIC FORREST, and Miss PEGGY PEARSON were elected Ordinary Members.

The PRESIDENT announced the death of Sir DYCE DUCKWORTH, the oldest member of the Society, and also of GEORGE MUIRHEAD, LL.D., who had been a member since 1878.

Dr. JAMES W. GREGOR read a paper: Observations on Timothy Grass and a Hybrid (*Phleum pratense* × *P. alpinum*), which he illustrated by lantern slides.

The following plants in flower were shown from the Royal Botanic Garden :— *Bulbophyllum tremulum* Wight ; *Catasetum macrocarpum* Rich. ; *Dendrobium delicatum* Bailey ; *Geranium crithmifolium* Poir. ; *Laelia Lundii* Rehb. f. ; *Loropetalum chinense* Oliver ; *Lycaste Skinneri* Lindl. var. *alba* ; *Maxillaria variabilis* Batem. var. *lutea* ; *Porphyrocoma lanceolata* Scheidw. ; *Primula Winteri* W. Wats. ; *Rhododendron argenteum* Hook. f. ; *Rh. mucronulatum* Turcz. ; *Rh. moupinense* Franch. ; *Saxifraga Biasoletti* × ; *S. Burseriana* Linn. var. *gloria* ; *S. Dörfleri* × ; *S. Hörhammeri* × ; *S. Kellereri* × ; *S. Sundermannii* × ; *Sedum compressum* Rose, and *Stiffia chrysantha* Mikan.

MARCH 13, 1928.

J. RUTHERFORD HILL, Ph.C., Vice-President, in the Chair.

Mr. GEORGE FORREST gave an account of the Scenery and Flora of Yunnan, and illustrated it with a large number of lantern slides, showing many plants in their native habitat.

Professor WRIGHT SMITH showed and explained two lantern slides representing diagrammatically the world-distribution of the Genus *Primula*.

APRIL 19, 1928.

J. RUTHERFORD HILL, Ph.C., Vice-President, in the Chair.

Mr. V. E. M. DAVY read a paper on Bolting in Root Crops.

Dr. R. J. D. GRAHAM and Mr. L. B. STEWART read a paper on Injection Experiments on Trees (see p. 19).

MAY 17, 1928.

SYMINGTON GRIEVE, Esq., Vice-President, in the Chair.

Mrs. KATE SUTHERLAND was elected an Ordinary Fellow.

Col. H. H. JOHNSTON communicated a paper on Additions to the Flora of Orkney, as recorded in Watson's "Topographical Botany," Second Edition (1883), which was illustrated by a number of interesting specimens collected by himself.

Col. H. H. JOHNSTON also communicated a paper on Additions to the Flora of Shetland.

Miss ELIZABETH W. MILLER read a paper on the Occurrence of Schizocotyly in certain Ranunculaceous Seedlings, and exhibited a number of specimens (see p. 21).

Professor WRIGHT SMITH exhibited *Primula Reidii* in flower and also cultivated plants of *Linnaea borealis* in flower.

Mrs. N. L. ALCOCK exhibited specimens of Plum Scab on twigs of Victoria Plums, from Galashiels.

JUNE 21, 1928.

J. RUTHERFORD HILL, Ph.C., Vice-President, in the Chair.

Professor BASIL WILLIAMS and Mrs. DOROTHY WILLIAMS were elected Ordinary Members.

The Chairman announced the death since the last meeting of Mr. JAMES A. FERGUSON, J.P., a Fellow of the Society.

Miss MARJORIE L. R. BOVELL read a paper : Note on a Circumnutation Record (see p. 46).

Miss C. I. KEAN read a paper on Light Receptors in Mesembryanthemum (see p. 37).

Miss C. I. KEAN also read a paper on Artificial Crystals in preserved tissue of Mesembryanthemum (see p. 43).

Mr. GEORGE TAYLOR exhibited some flowering plants from South Africa.

PROCEEDINGS
OF THE
BOTANICAL SOCIETY OF EDINBURGH.

SESSION XCIII

OCTOBER 18, 1928.

SYMINGTON GRIEVE, Esq., Vice-President, in the Chair.

The following Office-Bearers were elected for Session 1928-1929:—

PRESIDENT.

JOHN SUTHERLAND, (C.B.E., LL.D.).

VICE-PRESIDENTS.

SYMINGTON GRIEVE, Esq.
J. RUTHERFORD HILL, Ph.C.

Sir EVERARD IM THURN,
K.C.M.G., K.B.E.
HARRY GEO. YOUNGER, Esq.

COUNCILLORS.

D. ARMSTRONG, Esq.
E. M. BUCHANAN, Esq.
Professor MONTAGU DRUMMOND,
M.A., F.L.S., F.R.S.E.
W. EDGAR EVANS, B.Sc., F.R.S.E.
R. J. D. GRAHAM, M.A., D.Sc.,
F.R.S.E.
JAMES W. GREGOR, Ph.D.

DONALD PATTON, M.A., B.Sc.,
Ph.D.
WM. G. SMITH, B.Sc., Ph.D.
Professor W. WRIGHT SMITH, M.A.,
F.L.S., F.R.S.E.
MALCOLM WILSON, D.Sc., F.L.S.,
F.R.S.E.

Honorary Secretary—J. R. MATTHEWS, M.A., F.L.S., F.R.S.E.

Foreign Secretary—Very Rev. D. PAUL, M.A., D.D., LL.D.

Treasurer—ANDREW MASON, Esq., c/o RICHARD BROWN & Co., C.A.

Assistant-Secretary—J. T. JOHNSTONE, M.A., B.Sc.

Artist—R. M. ADAM.

Auditor—ROBERT C. MILLAR, C.A.

Mrs. AGNES D. MARTIN, Miss NORAH M'NAB THOMSON, Sir WILLIAM BURRELL, and CHARLES EDWARD FOISTER were elected Ordinary Fellows of the Society.

The Chairman announced the death of Mr. W. H. MASSIE, who had been a Fellow since 1902.

The Rev. J. J. MARSHALL L. AIKEN communicated the Scottish Alpine Club Report, 1927 (see p. 49).

Miss E. PHILIP SMITH communicated a paper on the Reaction of the Medium in relation to Root Formation in *Coleus* (see p. 53).

Mr. JAMES WRIGHT communicated a paper on the Causal Parasite of the Lily Disease (see p. 59).

Mr. R. M. ADAM exhibited a number of photographs illustrating Scottish Vegetation, and also exhibited some lantern slides illustrative of the Alpine Botanical Club Report.

Dr. R. J. D. GRAHAM and Mr. L. B. STEWART exhibited further examples of Vegetative Propagation (see pp. 67, 70).

Mr. R. M. ADAM exhibited specimens of Mistletoe as a Parasite on Lime.

The following plants in flower were shown from the Royal Botanic Garden : *Begonia prismatocarpa* Hook. ; *Calceolaria Burbidgei* × ; *C. Pavonii* Benth. ; *Crassula Bolusii* Hook. f. ; *Dendrobium Aphrodite* Reichb. f. ; *Epidendrum vitellinum* Lindl. var. *majus* ; *Erica grandiflora* Linn. f. ; *Hoheria populnea* A. Cunn. ; *Ixora coccinea* Linn. var. *Fraseri* ; *Petrocosmea Parryorum* C. E. C. Fisher ; *Pleione lagenaria* Lindl. ; *P. maculata* Lindl. ; *Rhipidoglossum rutilum* Schlechter ; *Rhodostachys bicolor* Benth. et Hook. f. ; *R. pitcairniaefolia* Benth. et Hook. f. and *Rondeletia odorata* Jacq.

NOVEMBER 15, 1928.

JOHN SUTHERLAND, C.B.E., LL.D., President, in the Chair.

The TREASURER, Mr. ANDREW MASON, submitted the following Statement of Accounts for Session 1927-1928 :—

INCOME.

Annual Subscriptions for 1927-1928	£53 10 0
Do. Arrears	5 0 0
Transfer from Life Members' Fund	21 8 0
Transactions sold	8 13 9
Interest on Funds Invested and in Bank	13 10 0
Subscriptions to Publications Fund	4 2 0
Income from Botanical Society Trust Fund	17 14 2
	<u>£123 17 11</u>

EXPENDITURE.

Printing <i>Transactions</i> for Session 1926-1927	£103 5 5
Printing and Postage of Notices for Meetings, etc.	21 2 0
Rooms for Meetings and Tea	7 3 1
Stationery, Postages, Advertising, etc.	4 4 9
Fire Insurance on Books, etc.	0 5 0
Honorarium to Treasurer	3 3 0
	<u>£139 3 3</u>
Excess of Expenditure	<u>£15 5 4</u>

STATE OF FUNDS.

Life Members' Fund.

Balance of Fund at close of Session 1926-1927	£278 12 0
Add: Life composition received	6 6 0
	<u>£284 18 0</u>
Deduct - Transferred to Income	21 8 0
Balance as at close of Session	<u>£263 10 0</u>

Ordinary Fund.

Balance of Fund at close of Session 1926-1927	£120 7 1
Deduct--Decrease during Session 1927-1928	15 5 4
	<u>105 1 9</u>
Balance as at close of Session, subject to expense of printing <i>Transactions</i>	<u>105 1 9</u>
Total Funds	<u>£368 11 9</u>

Being:—£200 5% War Stock, 1929-1947, at cost	£194 18 3
Sum in Current Account with Union Bank of Scotland, Ltd.	9 13 6
Sum in Deposit Receipt with do.	165 0 0
	<u>£369 11 9</u>
Less—Subscription received in advance	1 0 0

As above . £368 11 9

Note.—Subscriptions in arrear, considered recoverable: 1927-28, £5, 15s.

EDINBURGH, 1st November 1928.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for Session 1927-1928, and have found them correct. I have also checked the foregoing Abstract, and find it correct.

ROBT. C. MILLAR, C.A., Auditor.

BOTANICAL SOCIETY TRUST FUND.

INCOME.	
Interest on Funds invested	£17 14 2
EXPENDITURE.	
To Publications Fund	£17 14 2

EDINBURGH, 12th October 1928.—I have examined the books and vouchers of the Edinburgh Botanical Society Trust Fund, and certify the same to be correct.
ROBERT L. GORRIE.

Miss J. F. A. MACLAGAN, Mr. JOHN MURRAY, Mr. ALEXANDER H. CAMPBELL, Mr. ALASDAIR R. WILSON, and Mr. MICHAEL BRUCE were elected Ordinary Members.

Mr. GEORGE FORREST gave a lecture on Plant Communities of Yunnan, in which he described the zones of vegetation, especially of the gorges formed by the rivers Salween, Mekong, and Yangtse, where the elevation ranges from 6000 feet to 20,000 feet. The lecture was illustrated by a large number of lantern slides, many of them being in natural colours.

DECEMBER 13, 1928.

JOHN SUTHERLAND, C.B.E., LL.D., President, in the Chair.

The PRESIDENT expressed on behalf of the members their concern and regret at the continuance of the serious illness of HIS MAJESTY THE KING, who is Patron of the Society, and their hopes for his speedy recovery.

The PRESIDENT referred to the serious loss sustained by the Society through the death of Dr. W. G. SMITH on 8th December (see p. 175).

Mr. ROBERT R. CLARKE was elected an Ordinary Fellow.

Mr. SYMINGTON GRIEVE read a paper on Physical Changes brought about by the Floating Power of Seaweed (see p. 78). He illustrated his paper with numerous lantern slides and specimens.

The following plants in flower were exhibited from the Royal Botanic Garden: *Acacia alata* R. Br.; *Aphyllon uniflorum* A. Gray (parasitic on *Sedum acre*); *Brassavola cordata* Lindl.; *Calanthe Harrisii* ×; *C. Veitchii* Lindl.; *C. Wm. Murray* ×; *Canarina campanulata* Linn.; *Cymbidium Mastersii* Griff.; *Dendrobium subclausum* Rolfe; *Lycaste macrophylla* Lind. var.

Measuresiana; *Paphiopedilum Godfreyae* ×; *Peristrophe speciosa* Nees; *Streptocarpus Holstii* Engl., and *Tibouchina Moricandiana* Baill.

JANUARY 17, 1929.

JOHN SUTHERLAND, C.B.E., LL.D., President, in the Chair.

The PRESIDENT announced the death on 23rd December of Sir WILLIAM THISLETON-DYER, an Hon. British Fellow since 1888, and on the same day JOHN MERLE COULTER, an Hon. Foreign Fellow since June 1923.

Mr. SYMINGTON GRIEVE read the second part of his paper on Physical Changes brought about by the Floating Power of Seaweed (see p. 89). The paper was illustrated by a number of specimens and lantern slides. Mr. SYMINGTON GRIEVE also exhibited an unpublished letter from CHARLES DARWIN to himself on his researches.

Mr. DAVY exhibited an abnormal Swede.

The following plants in flower were exhibited from the Royal Botanic Garden: *Angraecum pertusum* Lindl.; *Bryophyllum crenatum* Baker; *Bulbophyllum tremulum* Wight; *Coelogyne sulphurea* Reichb. f.; *Crassula rosularis* Haw.; *Dermatobotrys Saundersii* Bolus; *Echeveria fulgens* Lem.; *E. multicaulis* Rose; *Eria globifera* Rolfe; *E. lobata* Reichb. f.; *Laelia anceps* Lindl. var. *Leemanii*; *Lycaste Lucianii* × var. *superba*; *L. Skinneri* Lindl. var. *alba*; *Masdevallia Schroederiana* Sander; *Oncidium Cebolleta* Sw.; *O. cheiroporum* Reichb. f.; *Ornithogalum aureum* Curt.; *Primula calciphila* Hutch.; *P. Winteri* W. Wats.; *Saccolabium bellinum* Reichb. f.; *Sedum compressum* Rose; *Veltheimia viridifolia* Jacq.; *Viburnum fragrans* Bunge; *V. grandiflora* Wall. and *Whitfieldia lateritia* Hook.

FEBRUARY 14, 1929.

SYMINGTON GRIEVE, Esq., Vice-President, in the Chair.

The CHAIRMAN announced the death of Miss BARKER, an Ordinary Fellow.

Mr. MATTHEWS read a paper on the Structure and Dehiscence of certain Poricidal Anthers by himself and Miss C. M. MACLACHLAN (see p. 104).

Mr. HUGH BOYD WATT communicated a paper on *Linaria Cymbalaria* in Scotland (see p. 123).

Dr. MALCOLM WILSON read a paper on *Aplanobacter Rathayi* causing a Disease of Cocksfoot.

Mr. MATTHEWS exhibited specimens of *Diphyscium foliosum* from Cumberland.

Mr. W. EDGAR EVANS exhibited a bone with *Tetraplodon mnioides* on it, which had been collected on Ben Lawers.

MARCH 14, 1929.

JOHN SUTHERLAND, C.B.E., LL.D., President, in the Chair.

Dr. JAMES CLARK gave a lecture on the Isles of Scilly, in which he gave a general account of the Islands, and dealt more particularly with their natural history. He illustrated the lecture with a fine series of lantern slides.

APRIL 18, 1929.

SYMINGTON GRIEVE, Esq., Vice-President, in the Chair.

Mr. CHARLES THOMSEN was elected an Ordinary Member.

The CHAIRMAN announced the death of Mr. R. C. MILLAR, C.A., who had acted as Auditor for the Society for many years (see p. 178).

Mr. A. B. BROWN read a paper: Observations on Leaf-fall in Douglas Fir when infected with *Rhabdocline Pseudotsugae*, which he illustrated with lantern slides.

MAY 16, 1929.

SYMINGTON GRIEVE, Esq., Vice-President, in the Chair.

The CHAIRMAN announced the death of Mr. WM. COLDSTREAM, who had been a Fellow of the Society since 1861.

Miss BARON read a paper on Cork Formation in *Rhododendron*, which she illustrated with lantern slides and specimens (see p. 127).

Mr. ROBERT R. CLARKE read a paper: Notes on Bracken Disease, which he illustrated with lantern slides.

JUNE 27, 1929.

Professor W. WRIGHT SMITH, M.A., F.R.S.E., in the Chair.

Mr. ROBERT CRAIG COWAN was elected an Ordinary Fellow.

The CHAIRMAN announced the death of Sir ARCHIBALD BUCHAN-HEPBURN, who had been a Fellow since 1894, and was President of the Society for Session 1912-1913, and also of Mr. ARTHUR BENNETT, who had been elected an Associate in 1886 (see p. 180).

Mr. W. BALFOUR GOURLAY communicated a paper on *Vaccinium intermedium* Ruthe on the South Pennine Moors and on Cannock Chase (see p. 131).

Dr. G. G. HAHN read a paper: Preliminary Report on a Variety of Red Currant Resistant to Weymouth Pine Rust (see p. 137).

Miss I. S. McNICOLL read a paper: Notes on Strand Plants.—III. *Salsola Kali* Linn. (see p. 147).

Mr. ALEXANDER PRATT read a paper: Notes on Strand Plants.—IV. *Arenaria peploides* Linn. (see p. 157).

Miss C. I. KEAN read a paper on Seedling Anatomy in *Mesembryanthemum* (see p. 164).

PROCEEDINGS
OF THE
BOTANICAL SOCIETY OF EDINBURGH.

SESSION XCIV

OCTOBER 24, 1929.

SYMINGTON GRIEVE, Esq., Vice-President, in the Chair.

The following Office-Bearers were elected for Session 1929-1930:—

PRESIDENT.

J. RUTHERFORD HILL, Ph.C.

VICE-PRESIDENTS.

W. EDGAR EVANS, B.Sc., F.R.S.E.	Professor R. A. ROBERTSON, M.A.,
Sir EVERARD IM THURN,	B.Sc., F.R.S.E.
K.C.M.G., K.B.E.	HARRY GEO. YOUNGER, Esq.

COUNCILLORS.

Mrs N. L. ALCOCK, F.L.S.	J. M. MURRAY, B.Sc.
Professor MONTAGU DRUMMOND,	DONALD PATTON, M.A., B.Sc.,
M.A., F.R.S.E.	Ph.D., F.R.S.E.
E. WYLLIE FENTON, M.A., B.Sc.,	JOHN SUTHERLAND, C.B.E.,
F.R.S.E.	LL.D., F.R.S.E.
R. J. D. GRAHAM, M.A., D.Sc.,	J. A. TERRAS, B.Sc.
F.R.S.E.	MALCOLM WILSON, D.Sc., F.L.S.,
SYMINGTON GRIEVE, Esq.	F.R.S.E.

Honorary Secretary—J. R. MATTHEWS, M.A., F.L.S., F.R.S.E.

Foreign Secretary—Professor W. WRIGHT SMITH, M.A., F.R.S.E.

Treasurer—ANDREW MASON, Esq.

Assistant-Secretary—J. T. JOHNSTONE, M.A., B.Sc.

Artist—R. M. ADAM.

Auditor—WILLIAM C. CALLENDER.

*TRANS. BOT. SOC. EDIN., VOL. XXX. PT. III., 1930.

Mrs KATE R. TERRAS was elected an Ordinary Fellow.

The Chairman announced the death, on 12th July, of the Rev. Dr. PAUL, who had been Hon. Foreign Secretary since 1906, and was President for sessions 1899-1901 (see p. 183).

Mr. GEORGE FORREST delivered an address on the Peoples and Customs of Yunnan, illustrated by a series of lantern slides. These included a number showing flowers of the country in their natural colours.

NOVEMBER 21, 1929.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

The PRESIDENT intimated that the Council had received the resignation of Mr. J. R. MATTHEWS as Hon. Secretary in consequence of his having been appointed to the Chair of Botany at Reading University.

Dr. R. J. D. GRAHAM was elected Hon. Secretary.

The TREASURER, Mr. ANDREW MASON, submitted the following Statement of Accounts for Session 1928-1929:—

INCOME.

Annual Subscriptions for 1928-1929	£56 10 0
Do. Arrears	4 15 0
Transfer from Life Members' Fund	20 19 0
Transactions sold	9 8 6
Interest on Funds Invested and in Bank	15 2 1
Subscriptions to Publications Fund	16 8 0
Income from Botanical Society Trust Fund	17 14 8
	<u>£140 17 3</u>

EXPENDITURE.

Printing <i>Transactions</i> for Session 1927-1928	£58 3 11
Printing and Postage of Notices for Meetings, etc.	21 9 9
Rooms for Meetings and Tea	7 7 0
Stationery, Postages, Advertising, etc.	5 7 6
Fire Insurance on Books, etc.	0 5 0
Honorarium to Treasurer	3 3 0
	<u>£95 16 2</u>
Excess of Income	£45 1 1

STATE OF FUNDS.

Life Members' Fund.

Balance of Fund at close of Session 1927-1928	. . .	£263 10 0
Add—Life composition received	. . . . .	<i>nil</i>
		<u>£263 10 0</u>
Deduct—Transferred to Income	. . . . .	20 19 0
		<u>£242 11 0</u>

Ordinary Fund.

Balance of Fund at close of Session 1927-1928	. . . . .	£105 1 9
Add—Increase during Session 1928-1929	. . . . .	45 1 1
		<u>150 2 10</u>
Balance as at close of Session, subject to expense of printing Transactions	. . . . .	150 2 10
		<u>£392 13 10</u>
Being:—£200 5% War Stock, 1929-1947, at cost	. . . . .	£194 18 3
Sum in Current Account with Union Bank of Scotland, Ltd.	. . . . .	8 10 7
Sum in Deposit Receipt with do.	. . . . .	190 0 0
Due by Treasurer	. . . . .	0 5 0
		<u>£393 13 10</u>
Less—Subscription received in advance	. . . . .	1 0 0
		<u>As above . £392 13 10</u>

Note.—Subscriptions in arrear, considered recoverable: 1927-28, £1; 1928-29, £6..

EDINBURGH, 5th November 1929.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for Session 1928-1929, and have found them correct. I have also checked the foregoing Abstract, and find it correct. I have seen the securities for the invested funds and have found them in order.

W. C. CALLENDER, Auditor.

BOTANICAL SOCIETY TRUST FUND.

INCOME.

Interest on Funds invested	£17 14 8
----------------------------	-----------	----------

EXPENDITURE.

To Publications Fund	£17 14 8
----------------------	-----------	----------

EDINBURGH, 14th October 1929.—I have examined the books and vouchers of the Edinburgh Botanical Society Trust Fund, and certify the same to be correct.

ROBERT L. GORRIE.

Mr. ALEXANDER B. BROWN and Miss F. B. MURRAY were elected Ordinary Fellows.

Miss EVA STUART WATT was elected a Lady Member.

Mr. E. WYLLIE FENTON read a paper entitled a Botanical Study of some Scottish Grasslands.

The following plants in flower were shown from the Royal Botanic Garden : *Aeschynanthus bracteata* Wall. ; *Bignonia buccinatoria* Mairet ; *Callicarpa purpurea* Juss. ; *Cuscuta reflexa* Roxb. ; *Dichorisandra thyrsiflora* Mikan ; *Erica grandiflora* Linn. f. ; *Fuchsia bacillaris* Lindl. ; *Iochroma tubulosa* Benth. ; *Masdevallia laucheana* Kraenz. ; *Mutisia retusa* Remy var. *glaberrima* ; *Nerine Bowdenii* W. Watson, *N. candida* Hort. ; *Odontoglossum McNabianum* × ; *Pleione maculata* Lindl. et Paxt. ; *Polygala Chamaebuxus* varr. *grandiflora* and *lutea* ; *Primula calciphila* Hutch. ; *Rhipidoglossum rutilum* Schlechter ; *Rhipsalis gracilis* N. E. Br. and *Streptocarpus Holstii* Engl.

DECEMBER 19, 1929.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

Mr. R. G. HEDDLE was elected an Ordinary Fellow.

Mr. H. B. GILLILAND, Mr. H. A. WEBER, and Mr. W. HANDYSIDE were elected Ordinary Members.

Mr. R. M. ADAM made the following motion :—

“ That this Society views with the gravest concern the threat to the Natural Scots Pine Forest caused by the Grampian Electricity Supply Bill, which is seeking powers to harness the waters of Glen Affric and Glen Cannich in the counties of Inverness-shire and Ross-shire.

“ In both Glens there are tracts of Natural Scots Pine Forest which have important interests for the naturalist, more particularly the forester.

“ The works projected by the ‘ Bill ’ threaten to destroy by submergence part of the old wood, while a ruthless destruction is likely to be the fate of the old specimen trees which form a belt above the water level.

“ It is urged that in view of these facts this Society take action and in the fullest measure bring pressure to bear on those who have the scheme in contemplation—seeking to make it imperative that as far as the measure will allow every possible means be taken to secure the preservation of the natural woodlands in either Glen.”

The PRESIDENT seconded the motion and Dr. SUTHERLAND spoke in support of it, and it was carried unanimously.

Mrs. N. L. ALCOCK gave an account of the places visited by her when with the British Association in South Africa, and illustrated her account with numerous lantern slides.

There were exhibited from the Royal Botanic Garden a large number of South African plants, some of which were in flower.

JANUARY 23, 1930.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

The Chairman announced the death of Mr. A. D. RICHARDSON, who had been an Associate since 1883.

Dr. J. W. GREGOR read a paper on Growth Forms within the Sea Plantain (*Plantago maritima* Linn.), which he illustrated with lantern slides.

Mr. J. H. WHYTE read a paper on the Recognition of some Agricultural Grasses by their Vegetative Characters (see p. 206).

Mr. SYMINGTON GRIEVE exhibited a spirally-twisted stem of Canadian Poplar.

The following plants in flower were exhibited from the Royal Botanic Garden: *Acacia Balfouriana* Woodr.; *Angraecum maxillarioides* Ridl.; *Crassula alpestris* Linn. f.; *Daedalacanthus nervosus* J. Anders.; *Dendrobium Chalmersii* F. Muell., *D. cymbidioides* Lindl., *D. subclausum* Rolfe; *Eria globifera* Rolfe, *E. lobata* Reichb. f.; *Peliosanthes humilis* Andr.; *Primula effusa* W. W. Sm. et Forrest, *P. malacoides* Franch.; *Sedum compressum* Rose and *Whitfieldia lateritia* Hook.

FEBRUARY 20, 1930.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

Mr. IVAN M. LAMB, Mr. D. MARSHALL, and Mr. J. RANKIN, junr., were elected as Ordinary Members.

Mr. R. M. ADAM gave an address on the Selection of a Site for a Scottish National Park. He first enumerated the considerations to be kept in mind when selecting a site and then considered the claims of several localities, laying greatest stress on Glen Affric. He showed a large number of lantern slides illustrative of the various possible sites (see p. 187).

The following plants in flower were shown from the Royal Botanic Garden: *Begonia laciniata* Roxb. ♂ and ♀; *Bulbophyllum comosum* Hemsl.; *Coelogyne intermedia* ×; *Cotyledon fulgens* Baker; *Cymbidium Wilsoni* Rolfe; *Illicium floridanum* Ellis; *Laelia harpophylla* × Reichb. f.; *Loropetalum chinense* Oliv.; *Magnolia denudata* Desr.; *Masdevallia Schroederiana* Sander; *Oncidium Cebolleta* Sw.; *Ornithidium densum* Reichb. f.; *Platyclinis glumacea* Benth.; *Rhododendron argenteum* Hook. f., *Rh. irroratum* Franch. and *Rh. moupinense* Franch.

MARCH 20, 1930.

SYMINGTON GRIEVE, Esq., in the Chair.

Mr. ERIC DRABBLE communicated a paper entitled a List of Scottish Pansies (see p. 190).

Dr. MALCOLM WILSON read a paper on a Disease of Spruce Cones caused by *Ascochyta piniperda*, and illustrated it with lantern slides.

Miss M. H. SMITH read a paper on Leaf Anatomy of the British Heaths, and illustrated it with specimens and lantern slides (see p. 198).

Mr. L. B. STEWART exhibited specimens of Elm showing old pruning, and also haustoria of *Cuscuta reflexa* showing vegetative growth.

The following plants in flower were shown from the Royal Botanic Garden: *Aeridovanda Mundyi* ×; *Arpophyllum giganteum* Hartw.; *Blaeria spicata* Hochst.; *Camellia reticulata* Lindl.; *Crassula barbata* Linn f.; *Dendrobium delicatum* Bailey; *Erica campanulata* Andr., *E. laevis* Andr., *E. speciosa* Andr.; *Kalanchoe Dyeri* N. E. Br.; *Lycaste Lucianii superba* ×, *L. plana* Lindl. (Temple's var.), *L. Skinneri* Lindl. var. *alba*; *Morisia hypogaea* J. Gay; *Physosiphon Moorei* Rolfe; *Scilla verna* Huds. and *Soldanella montana* Willd. var. *hungarica*.

APRIL 24, 1930.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

Mrs. MENIE WATT was elected an Ordinary Fellow.

Mr. THOMAS ROBSON was elected an Ordinary Member.

Mr. J. H. WHYTE read a paper on Bracken Sporelings (see p. 209).

Dr. R. J. D. GRAHAM read a paper by himself and Mr. L. B. STEWART on Experiments with Vita Glass (see p. 212).

MAY 15, 1930.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

Mr. L. B. STEWART read a paper by Dr. R. J. D. GRAHAM and himself on Vegetative Propagation of Broccoli, which he illustrated with specimens (see p. 216).

Miss LUCY BOYD read a paper on Development and Anatomy of Monocotylous Seedlings—1. *Paris*; 2. *Costus*—which she illustrated with diagrams and specimens (see p. 218).

Sir EVERARD IM THURN exhibited some fasciated Tulips.

JUNE 19, 1930.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

Miss E. PHILIP SMITH read a paper on Flower Colours as Natural Indicators (see p. 230).

Professor J. R. MATTHEWS communicated a paper on Galloway Roses (see p. 239).

Mr. C. E. FOISTER exhibited a rare parasitic fungus on *Myrica Gale* (see p. 244).

Miss MOIR exhibited and explained a twenty-four-hour chart of the Circumnutation of *Helianthus tuberosus*.

PROCEEDINGS
OF THE
BOTANICAL SOCIETY OF EDINBURGH

SESSION XCV

OCTOBER 16, 1930.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

The following Office-Bearers were elected for Session 1930-1931 :—

PRESIDENT.

J. RUTHERFORD HILL, Ph.C.

VICE-PRESIDENTS.

W. EDGAR EVANS, B.Sc.

SYMINGTON GRIEVE, Esq.

Professor R. A. ROBERTSON, M.A.,
B.Sc.

JOHN SUTHERLAND, C.B.E., LL.D.

COUNCILLORS.

Mrs. N. L. ALCOCK, F.L.S.

Miss LUCY BOYD, B.Sc.

WM. C. CALLENDER, Esq.

ROBERT CRAIG COWAN, Esq.

E. WYLLIE FENTON, M.A., B.Sc.

JAMES W. GREGOR, Ph.D., F.L.S.

Sir EVERARD IM THURN,

K.C.M.G., K.B.E.

J. M. MURRAY, B.Sc.

ALEX. NELSON, B.Sc., Ph.D.

J. A. TERRAS, B.Sc.

Honorary Secretary—R. J. D. GRAHAM, M.A., D.Sc.

Foreign Secretary—Professor W. WRIGHT SMITH, M.A.

Treasurer—ANDREW MASON, Esq.

Assistant-Secretary—J. T. JOHNSTONE, M.A., B.Sc.

Artist—R. M. ADAM, Esq.

Auditor—WM. C. CALLENDER, Esq.

TRANS. BOT. SOC. EDIN., VOL. XXX. PT. IV., 1931.

Mr. ROBERT MURRAY, Dr. J. M. COWAN, and Mr. Wm. B. STEEL were elected Ordinary Fellows.

The PRESIDENT announced the death of Mr. E. M. HOLMES, who had been a Fellow since 1878.

Mr. R. E. COOPER read a paper, Notes on the Flora of Bhutan, which he illustrated with numerous lantern slides.

Mr. R. M. ADAM communicated the Reports of the Scottish Alpine Botanical Club for 1928 and 1929 (see pp. 246, 250).

NOVEMBER 20, 1930.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

The PRESIDENT announced the death of Mr. E. H. WILSON, an Honorary Foreign Member, and of Mr. JAMES CURRIE, LL.D., an Ordinary Fellow.

Mr. SYMINGTON GRIEVE read a paper, More about the Floating Power of Seaweed, and also a paper on Researches in connection with the Decomposition of Seaweed and the Generation of Gas.

The following plants in flower were shown from the Royal Botanic Garden: *Acampe papillosa* Lindl.; *Angraecum caespitosum* Rolfe; *Aphelandra nitens* Hook. f.; *Callicarpa purpurea* Juss.; *Cephalangraecum glomeratum* Schlechter; *Cestrum Smithii* Hort.; *Coelogyne miniata* Lindl.; *Columnnea gloriosa* Sprague var. *superba*; *Cymbidium giganteum* Wall.; *Dendrobium amplum* Lindl.; *Erica decipiens* Spreng. f.; *Jasminum rex* Dunn; *Pleione maculata* Lindl. et Paxt.; *Pleurothallus Scapha* Reichb. f.; *Ponera juncifolia* Lindl.; *Rhipidoglossum rutilum* Schlechter; *Rhodostachys bicolor* Benth. et Hook. f.; *Rondeletia odorata* Jacq.; *Salvia uliginosa* Benth., and *Sonerila argentea* Hort.

DECEMBER 18, 1930.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

The TREASURER, Mr. ANDREW MASON, submitted the following Statement of Accounts for Session 1929-1930:—

INCOME.

Annual Subscriptions for 1929-1930	£58 0 0
Do. Arrears	4 15 0
Transfer from Life Members' Fund	21 4 0
Transactions sold	12 0 6
Interest on Funds Invested and in Bank	13 11 9
Subscriptions to Publications Fund	7 5 0
Income from Botanical Society Trust Fund	17 8 10
	<u>£134 5 1</u>

EXPENDITURE.

Printing <i>Transactions</i> for Session 1928-29	£98 7 1
Printing and Postage of Notices for Meetings, etc.	20 14 6
Rooms for Meetings and Tea	7 7 9
Stationery, Postages, Advertising, etc.	5 16 2
Fire Insurance on Books, etc.	0 5 0
Income Tax on Untaxed Interest (4 years)	10 4 0
Honorarium to Treasurer	3 3 0
	<u>£145 17 6</u>

Excess of Expenditure	<u>£11 12 5</u>
---------------------------------	-----------------

STATE OF FUNDS.

Life Members' Fund.

Balance of Fund at close of Session 1928-29	£242 11 0
Add—Life composition received	10 10 0
	<u>£253 1 0</u>
Deduct—Transferred to Income	21 4 0
	<u>£231 17 0</u>

Ordinary Fund.

Balance of Fund at close of Session 1928-1929	£150 2 10
Deduct—Decrease during Session 1929-1930	11 12 5
	<u>138 10 5</u>
Balance as at close of Session, subject to expense of printing <i>Transactions</i>	138 10 5
Total Funds	<u>£370 7 5</u>

Being :—£200 5% War Stock, 1929-1947, at cost	£194 18 3
Sum in Current Account with Union Bank of Scotland, Ltd.	15 14 2
Sum in Deposit Receipt with do.	160 0 0
Due by Treasurer	3 0 0
	<u>£373 12 5</u>

Less—Subscription received in advance 3 5 0

As above £370 7 5

Note.—Subscriptions in arrear, considered recoverable, 1928-29, £1, 15s. ; 1929-30, £3.

EDINBURGH, 28th November 1930.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for Session 1929-1930, and have found them correct. I have also checked the foregoing Abstract, and find it correct. I have seen the securities for the invested funds and have found them in order.

W. C. CALLENDER, Auditor.

BOTANICAL SOCIETY TRUST FUND.

INCOME.

Interest on Funds invested	<u>£17 8 10</u>
--------------------------------------	-----------------

EXPENDITURE.

To Publications Fund	<u>£17 8 10</u>
--------------------------------	-----------------

EDINBURGH, 1st December 1930.—I certify that I have examined the books and vouchers of the Edinburgh Botanical Society Trust Fund, and certify the same to be correct.

ALEX. ARNOTT.

Professor WILLIAM HENRY LANG was elected an Honorary British Fellow.

Miss A. W. DICKSON, Mr. CHARLES MUIRHEAD, Mr. H. C. TORBOCK, and Mr. JAMES H. WHYTE were elected Ordinary Fellows.

Mr. J. BOWDEN was elected an Ordinary Member.

Mr. C. E. FOISTER read a paper on the White Tip Disease of Leek, which he illustrated with lantern slides (see p. 257).

Mr. HAROLD F. COMBER read a paper on Plant Collecting in the Andes, which he illustrated with a large number of lantern slides of scenery and of individual plants.

FEBRUARY 19, 1931.

Professor W. WRIGHT SMITH, M.A., in the Chair.

Mrs. HAROLD COWIE, Mr. G. L. ALLARDYCE, Major-General GRANVILLE EGERTON, and Mr. T. A. S. FORTUNE were elected Ordinary Fellows.

Mr. JAMES A. MACDONALD was elected an Ordinary Member.

The CHAIRMAN announced the death of Professor OSTENFELD, an Hon. Foreign Fellow, of Capt. WM. STEWART of Shambellie, an Ordinary Fellow, and of Professor BEIJERINCK, who had been a Corresponding Member since 1905.

Miss CADMAN read a paper on the Life History of *Didymium nigripes*, which she illustrated with lantern slides.

Mrs. MARY J. F. GREGOR read a paper on Heterothallism in *Ceratostomella*, which she illustrated with lantern slides.

Miss HERRING exhibited specimens of the common diseases of apples.

The following plants in flower were shown from the Royal Botanic Garden: *Aster reflexus* Linn.; *Clematis cirrhosa* Linn.; *C. Forrestii* W. W. Sm.; *Coelogyne Parishii* Hook.; *Cyclamen libanoticum* Hildebr.; *Dendrobium aemulum* R. Br., *D. delicatum* Bailey, *D. gracilicaule* F. Muell., *D. subclausum* Rolfe; *Lilium roseum* Wall. var. *Thomsonianum*; *Loropetalum chinense* Oliver; *Lycaste Lucianii* ×; *Odontoglossum Rossii* Lindl.; *Oncidium splendidum* A. Rich.; *Prostanthera rotundifolia* R. Br.; *Skimmia Veitchii* Carr.; *Soldanella alpina* Willd. var. *alba*; and *Whitfieldia lateritia* Hook.

MARCH 19, 1931.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

The PRESIDENT announced the death of Dr. LENNOX, who had been a non-Resident Fellow since 1878.

Mr. R. M. ADAM gave an account of the visit of the Scottish Alpine Botanical Club to Braemar and Glenshee, which he illustrated with a large number of lantern slides.

The following plants in flower were shown from the Royal Botanic Garden: *Agapetes Moorei* Hemsl., *A. buxifolia* Nutt.; *Camellia reticulata* Lindl.; *Crassula columnaris* Linn. f.; *Dendrobium Beckleri* F. Muell., *D. linguiforme* Sw., *D. speciosum* Sm., *D. tetragonum* A. Cunn.; *Eria obesa* Lindl.; *Greenovia diplocycla* Bolle; *Kitchingia campanulata* Baker; *Moricandia sonchifolia* Hook.; *Pentapterygium serpens* Klotzsch; *Rhododendron arboreum* Sm. var. *album*, *Rh. barbatum*, G. Don, *Rh. calophyllum* Franch., *Rh. irroratum* Franch., *Rh. lutescens* Franch., *Rh. spinuliferum*, Franch. and *Vanda Bensoni* Batem.

APRIL 23, 1931.

Professor W. WRIGHT SMITH, M.A., in the Chair.

The CHAIRMAN announced the death of Professor W. A. McINTOSH of St. Andrews (see p. 251).

Dr. GRAHAM read a paper by himself and Mr. STEWART on Leaf Propagation of *Acalypha*, *Gasteria*, and *Dioscorea*, and illustrated it with a number of specimens (see p. 282).

Mr. J. T. JOHNSTONE exhibited a series of coloured pictures of flowers published by Dr. THORNTON, c. 1795-1808.

MAY 21, 1931.

SYMINGTON GRIEVE, Esq., Vice-President, in the Chair.

Mr. H. A. LATHAM was elected an Ordinary Fellow.

Mr. H. B. GILLILAND read a paper on the Occurrence of Cortical Bundles in the Stem of *Ruscus aculeatus* Linn., which he illustrated with diagrams and microscopic slides (see p. 284).

Mr. M. Y. ORR exhibited a number of specimens showing fasciation and other abnormalities of form and structure.

JUNE 18, 1931.

J. RUTHERFORD HILL, Ph.C., President, in the Chair.

Miss LUCY BOYD read a paper on Evolution in the Monocotyledonous Seedling: a new Interpretation of the Morphology of the Grass Embryo, which she illustrated with diagrams (see p. 286).

A series of papers—Notes on Salt-Marsh Plants, were read :
(1) *Glaux maritima* Linn., by Miss MARGARET A. MOIR (see p. 304); (2) *Plantago maritima* Linn., by Mr. DAVID F.

STEWART (see p. 313); (3) *Triglochin maritimum* Linn., by Mr. JAMES PARK (see p. 320). Each of these papers was illustrated with diagrams.

Dr. E. PHILIP SMITH read a preliminary paper on Stomatal Movement by Miss M. I. JOLLY and herself.

Miss J. J. STEVENSON exhibited two Weaver Birds' Nests from Sungei Patani, Kedah.

TRANSACTIONS
OF THE
BOTANICAL SOCIETY OF EDINBURGH

SESSION XCII

NOTES ON CAITHNESS PLANTS. By ARTHUR BENNETT, A.L.S.

(Read 17th November 1927.)

These notes comprise any additions and new localities that have come to my notice since the publication of my last notes in the Transactions of this Society, vol. xxix, p. 54 (1924), as I hope that some day a Flora of the county will be prepared.

Viola lepida Jord.—Side of Wick River. Druce in Bot. Exch. Club Rep. for 1923, p. 171.

Viola Pesneaui Lloyd.—Dunnet Links. Druce, *loc. cit.*, p. 172.

Cerastium tetrandrum Curt. var. *eglandulosum* C. E. Salm.—Salmon in Jour. Bot., lxi (1923), p. 90.

Geranium lucidum Linn.—Near Lybster, G. Lillie, sp.

Artemisia vulgaris Linn. var. *coarctata* Forselles.—Coast near Lybster, G. Lillie, sp.

Thymus britannicus Ronn.—Thurso, Grant.

Atriplex glabriuscula Edmondst. var. *pseudo-calotheca*, var. nov.

Folia ad *calotheca* accedens, fructus longus muricatus. Coast at Reiss, G. Lillie, sp.

The specimens of this species on the Caithness coast vary considerably, but most of them are far more muricate than usual.

Atriplex glabriuscula \times *maritima*.—Specimens gathered near Reiss, where the two grow together, are evidently a hybrid between them. The leaves and habit resemble the latter, while the fruit is more like the former.

Carex turfosa Fries.—Banks of the river near Wick, J. Grant, sp.

Carex Goodenowii Gay var. *juncella* Fr.—Meadow by Wick River, near Wick, E. S. Marshall, sp.

Carex binervis Sm. var. *alpina* Drej.—Near Wick, J. Grant, sp.

Carex Kattegatensis Fries, in Ind. Sem. Hort. Upsala (1857).—This is one of the most interesting Caithness plants. It is very rare in Europe, being recorded only from Bohuslän, Sweden, and Christiania (Oslo), Norway. Mr. Grant of Wick writing some years ago mentions that this *Carex* is plentiful in the Thurso River, growing with *C. aquatilis*, and is one of the earliest species to flower, the flowers appearing about the end of March.

NOTES ON THE EFFECT OF CUTTING BRACKEN (*PTERIS*
AQUILINA L.). By WILLIAM G. SMITH, B.Sc., Ph.D.

(Read 19th January 1928.¹)

The Bracken fern is a well-known pest for the sheep farmer and forester. It is a heritage of the earlier woodlands, left as a dominant plant on the deeper soils formerly occupied by trees. Thence it has spread in a considerable degree into grassland and into heather, suppressing these by the dense shade of its living fronds in summer and by the covering of dead fronds in winter. The dense thickets also exclude sheep, hence many acres are rendered useless for grazing. An urgent need is a cheap and effective method for its destruction or restriction. Since the underground parts are too deep in the soil to be reached by any implement except the plough, the methods used are directed towards destroying the fronds by cutting, grazing, or spraying.

Experiments on Bracken are included in the investigations on hill pasture in Boghall Glen on the Pentlands near Edinburgh, part of the farm of the Edinburgh and East of Scotland College of Agriculture. Plots were marked off on which the Bracken was cut annually at different dates, one series was begun in 1924, another in 1925. The Bracken here is a type less tall and less dense than the true woodland form, so that there is a continuous grass turf beneath it. The denser parts carry about 50 fronds per square yard, but there is variation from place to place.

The first appearance of fronds noted was 28th April 1925, 26th April 1926, and 5th May 1927, a late year. Cutting began on some plots in the last week in May, four weeks after first appearance, and was continued at intervals. The fronds on each plot were counted, and notes made on maturity, density, etc.

The general effects of cutting may be briefly summarised. The number of fronds in the second year, after one cutting, totalled about half of the original number. The plots did not appear to be much thinned, as the ground was still well covered,

¹ The notes were continued till July 1928, when the manuscript went to press.

but during the second cutting the fronds were noted as less robust and easier to cut. The result after two years' cutting was evident, as the plots were thinly covered because the fronds were smaller, but counts showed that the number of fronds cut in the third year was about the same as in the second. In the fourth year the plots were very scantily covered, but a count showed the number to be still considerable; thus where the original number was about 50 per square yard, there were still about 11 fronds per square yard at the fourth cut. The conclusion is that while three years' cutting uncovers the grass and leaves it open to grazing stock, yet it does not entirely remove the Bracken, so that if left it could return in time.

There is some difference of opinion as to best date for cutting, and this was tested. The following table gives details for one series of plots, each 93 square yards in area.

Year.	Appearance.	Plot I.		Plot II.		Plot III.		Plot IV.	
1925	28th April	Days.		Days.		Days.		Days.	
		35	2300	47	2400	57	..	65	
		65	1790						
1926	28th April		4090						
		33	830	44	1240	50	1335	63	1344
		63	1400						
1927	5th May		2230						
		31	778						
		73	1087	45	1260	53	1154	63	1000
		Oct.	670	Oct.	1600	Oct.	1134	Oct.	692
			2535		2860		2288		1692

The first appearance of fronds varied about a week during the four years of observations, and the dates of cutting are given as the number of days after the first record—that is, from about 1st June till the first week of July. In 1925, first year of cutting, the original number was ascertained on only two of the four plots, but approximately the total number was 5000 or 50 per square yard. In 1925 and 1926 the numbers do not

include fronds that developed after the date of cutting, but in 1927, in October when the fronds were brown, a count was made to ascertain the later growth. The yearly figures for Plot I, and for each plot in 1927, show that this later development of fronds is considerable, even after cutting at nine or ten weeks old. These late fronds were generally small, but on Plot II many of the later ones became tall and strong, so that they must have built up a considerable amount of reserve food for storage in the rhizomes. A comparison of the three years shows that after one year's cutting, the next crop is about half the original number. After two years' cutting the numbers fall only slightly, but there is a considerable reduction in the average size of frond.

In the fourth year, 1928, the fronds were not cut but were counted at thirty-six days and sixty-seven days. On the latter date, 6th July, the normal Bracken fronds are nearly all over a foot high, but on the plots the condition will be seen from the large number of small ones :—

1928, first fronds seen 1st May.

	Plot I.	Plot II.	Plot III.	Plot IV.	
36 days	359	578	358	217	
67 days	553	934	613	336	(less than 1 foot)
	58	112	41	18	(over 1 foot)
	<hr/> 611	<hr/> 1046	<hr/> 654	<hr/> 354	

The most evident number is that for Plot II, cut each year in the second week of June and still carrying about a fourth of its original number of fronds. This is confirmed by the appearance of the plots in July 1928, IV is distinctly thin, II has a considerable cover, and the other two are intermediate. As the second cutting of Plot I and the single cut of Plot IV were made about the same day, a better agreement was expected, but in the absence of a count for the 1925 cut for IV, it is not known whether this plot was originally less dense.

These observations support the view that early cutting or switching of the young fronds only destroys the early ones, leaving from a half to two-thirds of the normal crop of that year to develop. These grow to a large size and if not cut again will actively nourish the plant till September. Cutting about 1st July, when the fronds are about nine weeks old,

removes most of the fronds after they have used up the food reserves and before they have time to replenish the loss.¹ This means a short season for cutting to get the best results.

An experiment was begun in 1927 to test whether an application of common salt might not induce the sheep to eat Bracken. When the curled fronds were appearing above the ground in May, a plot was dressed with crushed rock salt (2 cwt. per acre). The sheep soon found the plot and there were indications of increased grazing. The top-dressing was twice repeated during May, with the result that the grass was much grazed and many Bracken fronds were seen broken off or partially bitten while still in the curled stage. Two equal areas were counted, 8th July, and gave the following numbers of fronds: Unsalted Bracken, 500 or 30 per square yard; salted, entire fronds 178, bitten or broken off 100 fresh, and others too shrivelled to count. The effect was that the number of fronds was reduced by over a half by the sheep. In 1928 the thinned plot is still recognisable, and the salting was repeated twice. The effect of salting in May, followed by a cutting in July, tried on another plot, was a considerable thinning of the plot in 1928.

The effect of sodium chlorate, a recently introduced weed killer, was tested in 1928. On one plot 2 oz. per square yard was applied as solution in water; other plots were top-dressed with dry crystals at rates varying from $\frac{1}{2}$ oz. to 3 oz. per square yard. The applications were made in the middle and at the end of May on the young fronds. The result was that the fronds became dark and shrivelled, and so brittle that they snap off just below the leafy part, so that only frond stalks were left. The grass below is also destroyed. At the end of July very few fronds had appeared, a result more effective than cutting at the end of May, for a cut plot would at the end of July carry many fronds, whereas the chlorate plot is bare. The smaller dressing, $\frac{1}{2}$ oz. per square yard, was found to be fairly efficient, and further tests are in progress.

An examination of the underground parts of the Bracken has been made at intervals. The most complete samples were taken in November 1927 from four places: (a) uncut, (b) cut twice for three years, (c) cut in first week of July for

¹ See also "The Eradication of Bracken," J. H. Milne Home (*The Scottish Journal of Agriculture*, ix. 123-129, 1926).

three years, (d) cut four years. The method was to collect all the parts of Bracken found in a hole 2 feet by 2 feet at the surface, down to about 18 inches, below which there was none.

The underground parts of the Bracken consist of two main parts, a deeper system of thicker storage rhizomes from a half to 1 inch in diameter, with lateral branches but with few fronds. Nearer the surface there is a system of thinner rhizomes closely beset with traces of petioles and with a dense covering of fine roots. The latter are referred to as frond-bearing branches, while the thicker ones are vegetative or storage rhizomes.

The amount of rhizomes may be large, and in this case the four holes yielded respectively 52, 56, 82, and 99 feet. This means that the rhizomes are closely packed up to near the surface. The lesser amounts were taken from places where the fronds were less dense.

Each rhizome and frond-bearing branch has its origin from a terminal growing-point, easily recognised as a blunt cone (fig. 1). Soon after its formation the apical cell divides and the terminal becomes a double emergence. One growing-point is larger and gives rise to a horizontal axis, the elongation of the rhizome. The other growing-point, the frond-lateral, is at first minute and lies in a slight groove on one side of the rhizome. This ultimately gives rise to a frond, and as these laterals arise alternately to right and left of the rhizome, so the fronds occur in two rows. The leafy frond of any year arises some distance (up to some inches) behind the terminal growing-point. The course of development given in the text-books was described by Hofmeister about 1850, but some deviations were found in the material from our Bracken plots. The normal sequence is: (a) the leafy frond of the present year, (b) a club-shaped bud enclosing a curled rudimentary frond, (c) the frond-lateral bud, (d) the rhizome apical bud. If only one frond were matured each year, say 1927, then the club-shaped bud contains the frond for 1928, and the lateral part of the terminal will produce the frond of 1929. Later stages of growth include elongation of the terminal growing-point, so that the successive laterals become distributed at intervals along the rhizome. Elongation is limited to the part beyond the frond of the present year, and when the club-

shaped bud has been formed there can be little elongation between it and the green frond.

The leafy frond arises from a lateral bud, and at the base of each rachis, on the proximal side, there is a growing-point that remains after the decay of the frond ; a few cases have been

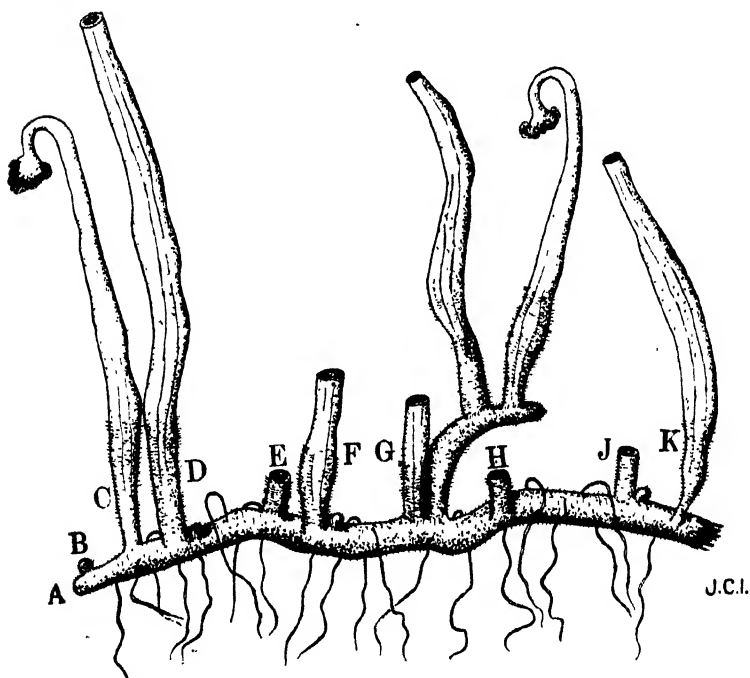


FIG. 1.—Terminal part of Bracken rhizome in May 1928 ; from a plant cut each year, 1925–1927.

A. Terminal growing-point. B. Frond-lateral growing-point. C. Unfolding frond of 1928. D. Petiole base 1927, with basal growing-point. E. Base of a small frond. F. Base of a larger frond with basal growing-point ; both E and F probably unfolded in 1926. G. Petiole base, frond 1925 ; the basal bud has formed a branch with a frond unfolding in 1928. H, J, K. Petiole bases 1924, 1923, and 1922.

observed where this bud is double. This growing-point has three possibilities : (a) it may become a lateral branch, either vegetative or frond-bearing, (b) it may give rise to a second frond, (c) it may remain dormant (fig. 1). Dormant growing-points may be found at the base of fronds that were leafy over ten years ago, three cases were seen at fifteen years and one at eighteen. It follows that the vegetative rhizomes may be

living and vigorous up to twenty years, and capable of giving off new branches or fronds. The vegetative rhizomes do not branch freely, and most of the laterals become frond-bearing. The distance between old petiole spurs is a measure of the annual extension of the rhizome. These spurs are frequently 6 to 8 inches apart, but cases have been measured up to 20 inches. The greater elongation of the rhizome takes place in the earlier stages when the Bracken is invading suitable soil. Later, when the rhizomes become crowded, and competition for water, etc., becomes more acute, the distances are reduced.

When a frond-bearing branch arises from the deeper-seated rhizomes it inclines upwards towards the surface and apical extension is reduced, hence the petiole scars are closer, generally less than an inch. As the extremity of the branch approaches the surface it was observed that the buds and fronds became smaller, and in some cases growth had ceased. The crowding of buds was very evident in the two trial holes with 99 and 82 feet of rhizome. The effect of cutting is to increase crowding on the parts formed after cutting had begun.

When the rhizomes from trial holes were examined, depletion of the larger storage rhizomes was evident. Those from an uncut area were plump and hard for long distances and only old parts showed decay. Rhizomes from the cut plots were shrunk from a short distance behind the growing-point, and they contained a milky fluid instead of the firm white tissue of normal Bracken. Considerable lengths of the older ones had a loose cortex, frequently ruptured so that long bands of the hard sclerenchyma were exposed as broad flat fibres. No growing-points were found on these parts. The depletion extends into the bases of the frond-bearing branches, but the younger extremities may still bear growing-points. The effect of rhizome depletion is to break up what was a wide-spreading continuous plant into a number of pieces or separate plants. The fronds will be produced from tufts of branches mainly near the surface, hence the water supply from the deeper soil layers will be reduced, and the more superficial root-system must compete for water with the grasses, etc., forming the grassy turf.

This depletion of the rhizomes was more evident in the two plots, I and IV, cut for three years in July, whereas on

Plot II, cut once each year in early June, there was a greater amount of unexhausted rhizome. This has been confirmed by the investigations of J. Hendrick (*Kew Bulletin*, No. 4, 1921). It is there shown from two series of analyses that the amount of food reserves, as expressed by soluble carbohydrates and nitrogen, diminishes steadily from April and reaches a minimum in July, after which there is an increase.

The starvation indicated by the smallness of the fronds after two years' cutting is also seen in the buds. Each frond bears a growing-point at its base, and with each year's cutting these become smaller. The reduction in the number of fronds indicates that many of these buds no longer produce fronds, but a proportion of them can develop even after four years' cutting.

Reference to the table given will show that a considerable number of fronds are unfolded after each cutting, even when as late as July. The fronds following the earlier cuts attain to a larger size, and may be regarded as normal buds unfolding late. The later ones, however, suggest a break-away from the normal. If the rhizomes are examined in winter, the rule is to find towards the extremity of each frond-bearing branch a single club-like frond-bud elongated up to about an inch, anterior to this is a lateral knob or growing-point, and then the rhizome growing-point. Examples have been found, however, where there are two club-like frond-buds, and during summer two leafy fronds have been observed, one beside the other on the same branch (fig. 2). This has been found in various localities, so that it is certain that a branch may produce two fronds in one year. This was indicated in 1884 by Klein (*Botan. Zeitung*, p. 557). In this paper he questions the accuracy of Hofmeister's assumption that only two leaf rudiments exist beyond the leafy frond, and he gives illustrations showing two lateral growing-points in material collected between April and October. His sequence is: 1st year, a frond lateral (*Blattanlage*) in the same groove as the apical growing-point; 2nd year, an emergence (*Hocker*) visible to the eye and gradually leaving the groove; 3rd year, formation of the club-like bud; 4th year, unfolding of the frond. Klein suggests that two fronds may mature in one year.

The effect of cutting has been to stimulate double frond development, for on the rhizomes from our plots there is fairly

frequently, as shown in fig. 1, a thick petiole base indicating

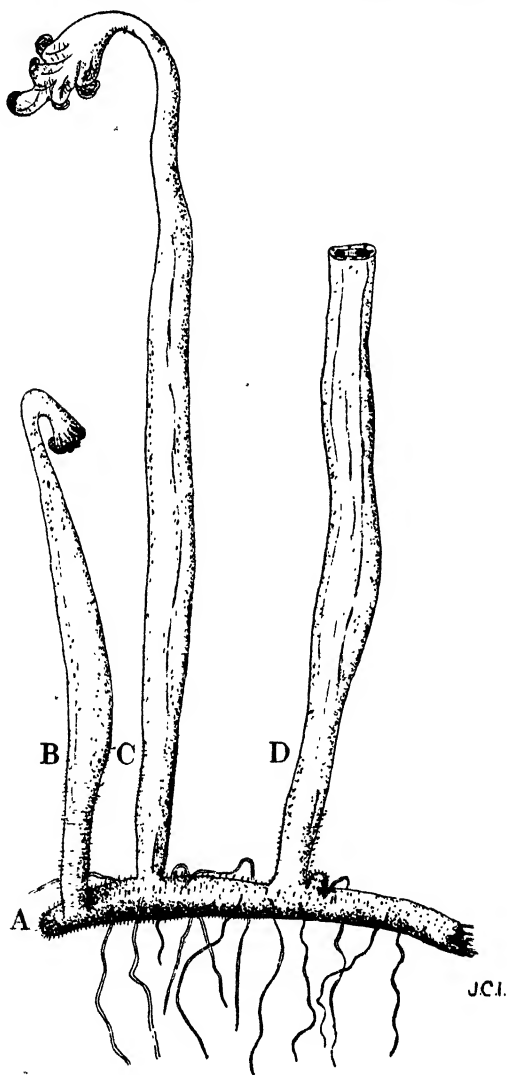


FIG. 2.—Apex of Bracken rhizome with two fronds unfolding in May 1928; from a plant cut each year, 1925–1927.

A. Terminal growing-point. B and C. Unfolding fronds. D. Petiole base 1927, with basal growing-point.

a large frond (the one cut), and a thin base, from a smaller frond cut later in the same year.

Another way in which additional fronds may arise is seen in fig. 1. Since the cutting began, one of the older growing-points has developed into a branch which has produced fronds.

The effects of cutting Bracken at the right season lead to the following results :—

(1) The fronds are removed at the stage when their formation has used up the greatest amount of food reserve in the rhizomes, but before they themselves have time to replenish the loss. At Boghall Glen this date is about 1st July, when the fronds have been eight to ten weeks above ground.

(2) Continued cutting gradually exhausts the rhizomes till the older parts die away, and the growing-points produced become smaller each year, so that any fronds arising from them are smaller.

(3) The continuous rhizome system is broken up by the decay of older parts, hence the fronds arise from detached groups of branches nearer the surface, and the supplies of water, etc., from the deeper soil layers are cut off.

(4) Cutting induces development of buds that would normally remain dormant for a year or longer.

A SEED-BORNE DISEASE OF CLOVER (*TRIFOLIUM REPENS* L.).

By N. L. ALCOCK, F.L.S. and M. S. MARTIN, B.Sc.
(With Pl. I.)

(Read 19th January 1928.)

The value of clover in pasture has been recognised for a long time—for at least two hundred years (5, 33). But the special value of our Wild White Clover that grows on the best old pastures and upland grazings in England and Scotland has only been appreciated during the last twenty or thirty years, and will always be associated with the name of Professor Gilchrist and Cockle Park (15). Much grassland was turned to arable during the war and is now returning to pasture, and the value of Wild White Clover as a component of the new herbage is admittedly great (19, 22). The importance of the source, the healthiness, and the strain of the seed used is gradually being recognised. Seed-borne disease is a factor that must be considered (18, 29, 30).

In samples of seed of *Trifolium repens*, L., imported into Britain from Central Europe and from New Zealand in 1927, there frequently occurred clover seeds apparently affected with a specific disease. These seeds were characterised by their peculiar colour—a grey-pink—which, on examination under a low magnification ($\times 16-20$), proved to be due to the presence of the mycelium of a fungus occurring in shining flecks on the surface of the seed coat. Associated with this characteristic symptom were brown, slightly depressed areas on the affected seeds. The infestation was specially characteristic of parcels of White Clover imported from New Zealand in 1927, in which diseased seeds occurred to an extent as great as 4 per cent. by weight. The diseased seeds were quite readily extracted from samples. Affected seeds extracted from a sample purporting to be Kentish Wild White Clover, but which was proved in legal proceedings to be seed of New Zealand origin, were submitted by the Seed Testing Station of the Board of Agriculture for Scotland to the Board's Pathological Department at the Royal Botanic Garden in

November 1927. The seeds were found, on examination, to be heavily infected with a fungus, the mycelium of which formed a loose mat under the seed coat of each seed (fig. 1).

The seeds were washed in mercuric chloride (1:1000) in order to destroy any adventitious spores on the outside, and then rinsed in sterile water. Whether the treatment affected the germination is uncertain. They germinated very badly, but probably that was owing to the disease. In any case the mercuric chloride was of no avail against the disease.

On 9th November some of them were planted on agar slopes and some on agar in Petri dishes for the purpose of obtaining cultures of the fungus. The medium used was oat agar.

The mycelium grew out readily, and began quickly to give concentric rings of small sclerotia which were at first white and studded with drops of water. By 24th November, *i.e.* in sixteen days, these sclerotia were fully formed and had become black and slightly warty. A few of the seeds were also damped after being washed and left in a sterile tube, where the sclerotia formed freely on the seeds themselves.

By 4th January the perfect stage began to appear in several of the cultures. The apothecia were produced in fair quantity, and the sclerotia did not seem to require a resting-stage. Some of the sclerotia not yet germinated were taken out of the tubes and were placed on sterilised wet sand and others on sterile wet cotton-wool. After the sclerotia were placed on the sand the apothecia appeared in from ten days to three weeks. The entire time from the culture of the mycelium in the seed to the apothecia was from 9th November to 4th January, on which date the first apothecia were seen. The apothecia were small, the discs ranging from $\frac{1}{2}$ to 2 mm. Each sclerotium threw up several stipes ranging in number from 1 to 14 (fig. 3).

At first short brown processes appeared on the sclerotia. These were rather dark brown. As they grew, they became paler and swelled at the tip—the latter at this time being the darkest part. Presently the club-shaped end opened into a funnel-shaped dark cup. After a time this cup opened out and became much paler in colour, especially the upper surface. The disc at full maturity was saucer-like or nearly flat, the colour of the spore-bearing surface becoming very

light pinkish buff, varying from a yellow to a pinkish shade. When fully grown, the stipes averaged 4–5 mm. in length, $\frac{1}{2}$ mm. in breadth, with the discs of the apothecia ranging from $\frac{1}{2}$ to 2 mm. across. The almost constant length of the stipes is attributed to the fact that they arose from sclerotia placed on top of the substratum. Had the sclerotia been buried at varying depths there would have been a corresponding variety in the length of the stipes (4). The average size of the asci in the hymenium is $186\ \mu$, and that of the spores $16.8\ \mu$ (fig. 4).

These apothecia that were grown on wet sand threw a great many spores against the lid of the Petri dish, the lid becoming almost milky-looking with the deposit. From these spores many more cultures were made successfully, and again produced the apothecia.

Infected seeds placed on filter-paper by Dr. Pethybridge at Harpenden (20th May 1928) produced sclerotia on the seeds, and by 28th June small apothecia appeared on the sclerotia. Similar sclerotia on the seeds themselves produced apothecia in Edinburgh on wet sand this summer. These apothecia that appeared on the sclerotia on the seed coat were in both cases very small (fig. 2, reproduced by kind permission of Dr. Pethybridge); those appearing from seed being even smaller than those that grew from sclerotia obtained in culture. In culture the mycelium produced was white, glistening, and of a sclerotinia type. After some weeks the agar tubes, full of small sclerotia, began to have small white dots on the mycelium. On examination these were found to be formed of the typical micro-conidia that have been described by other writers as occurring with the fungus *Sclerotinia trifoliorum* in culture and also in the field (4, 18, 31). Concurrently, a number of samples of English Wild White Clover were examined—at least twenty samples from many parts of England—but in no case was the sclerotinia found. Many cultures also were made from these samples, but the disease did not appear.

A series of experiments were carried out on the infection of clover plants, and these are still in progress. Pots of English Wild White Clover and New Zealand White Clover obtained from the Seed Testing Station, Corstorphine, were grown and sclerotia planted (26th April 1928) in the soil;

both sclerotia from the disease here described, and sclerotia from clover sickness from fields round Cambridge. A pot of seedlings of English Wild White Clover grown at the Royal Botanic Garden was also tried. Apothecia from this disease growing on sclerotia were also set under the plants. So far very little result has been seen. In one instance a positive result was obtained. A healthy seed of English Wild White was grown in a tube and the apothecial spores dusted on to the first two leaves on 26th April 1928. The plant became very sickly and yellow, and presently small black sclerotia came out on the base of the stem and on the roots. From this plant a culture was obtained, and the disease recovered as far as the sclerotial stage.

The sclerotinia species attacking the seed could be regarded as a small form of *Sclerotinia trifoliorum*, or possibly a dwarf variety of it. In culture the fungus agrees with the description of *Sclerotinia trifoliorum* given by Eriksson (8) or by Coleman (4) in respect of general appearance, growth, asci, and ascospores; the only divergence from published descriptions being in the size of the apothecia, particularly the disc—viz. $\frac{1}{2}$ to 3 mm. as compared with 1 to 10 mm. (Rabenhorst. Krypt. Flora. Rehm., iii, p. 817). In nature, however, the size of the disc varies very much, but the disc in this case has run persistently smaller than in *Sclerotinia trifoliorum*.

It is hoped that some more information as to the earlier stages of this disease, the method of infection, and the systematic position of the fungus will be obtained with further work.

SUMMARY.

In 1927-28 clover seed from Central Europe and from New Zealand was received at the Seed Testing Station, Edinburgh, infected by a fungus carried by a mat of resting mycelium below the seed coat.

This fungus was placed in culture and carried out its life-history, producing first, small black sclerotia, and from the sclerotia a crop of pinkish-brown apothecial cups. The ascospores produced in the cups reproduced the fungus. The average size of the asci was $186\ \mu$ and of the ascospores $16.8\ \mu$. The fungus agreed in size of asci, ascospores, and general life-history with that known as *Sclerotinia trifoliorum*,

but the size of the apothecia was smaller. In nature the size of the apothecia is exceedingly variable, but the cups throughout have followed a range of size below that of *Sclerotinia trifoliorum*.

One instance of reinfection and recovery has been noted.

REFERENCES.

- (1) ALLAN, H. H. : Vegetation of Mt. Peel. Trans. Proc. N.Z. Inst., lvii (1927).
- (2) AMOS, A. : Journ. Royal Agric. Soc. England, lxxix (1918), 68.
- (3) BAUDYS (MORAVIA) : Rev. Appl. Mycol., iii (1924), 582.
- (4) COLEMAN, L. C. : Kaiserl. Biol. Anst. Land u. Forstw. Berlin (1907), 469.
- (5) CURTIS, W. : Flora Londinensis, 3rd Fasc., Pl. 46 (1777).
- (6) DORPH-PETERSEN : Tidsskr. for Planteavl, xxxi, 1 (1925), 87.
- (7) ENGLER and PRANTL : Die natürlichen Pflanzenfamilien, Teil 1, Abt. 1.
- (8) ERIKSSON, J. : Fungoid Diseases of Agricultural Plants, p. 138.
- (9) ERITH, A. G. : White Clover (1924).
- (10) ESMARCH : Die Kranke Pflanze, ii (1925), 3 ; Rev. Appl. Mycol., iv, 42.
- (11) FLACHS : Prakt. Blätter für Pflanzenbau und Pflanzenschutz, v (1927), 69.
- (12) FRANCK, Dr. W. J. : Rijksproef-station voor Zaadcontrole, Wageningen, in correspondence (1927).
- (13) GENTNER, G. : Report of the Fourth International Seed Testing Congress (1924), 113.
- (14) ERIKSSON and BENNETT : Phytopathology, vii (1917), 432.
- (15) GILCHRIST, D. A. : Trials of Wild White Clover. Journ. Bd. Agric., xvi (1909), 713, and xxii (1916), 1063.
- (16) HALL, Sir DANIEL : Fertilisers and Manures, pp. 34, 297, 324.
- (17) — : Book of the Rothamsted Experiments, pp. 133, etc.
- (18) JACZEWSKI, A. : Publ. Min. Agric. Bureau Mycol. and Pathol. Scientific Committee, Tula, Russia (1916), p. 17.
- (19) JENKIN, T. J. : Ordinary White Clover *versus* Wild White Clover Seed. Journ. Bd. Agric., xxiii (1917), 1202.
- (20) KØLPIN, RAVN. : Smitsomme Sygdomme hos Landbrugsplanterne (1927), p. 134.
- (21) LAUBERT, R. : Mitt. Kaiserl. Biol. Anst. Land u. Forstw. (1912), No. 12, p. 17.
- (22) M'ALPINE, A. N. : Wild White Clover. Trans. Highland and Agric. Soc. of Scotland, xxvii (1915), 238.
- (23) PRILLIEUX : Maladies des Plantes Agricoles, ii, 413.
- (24) RAMSEY, G. B. : Sclerotinia Species causing Decay of Vegetables. Journ. Agric. Res., xxxi (1925), 597.
- (25) ROSTRUP : Tidsskr. for Landökonomie (1890).
- (26) SINCLAIR, G. : Hortus Gramineus Woburnensis (London, 1826).
- (27) SOMERVILLE, W. : Poverty Bottom. Misc. Public Board of Agric. (1918).
- (28) SORAUER : Handbuch der Pflanzenkrankheiten, ii (1908).

- (29) STAPLEDON, R. G. : Herbage Seed Production in New Zealand. Journ. Min. Agric., xxxiv (1927).
- (30) TROUSSOVA : Varietal resistance to *Sclerotinia trifoliorum* and to a blossom wilt, *Botrytis anthophila*. Rept. Moscow Land Admin. Sect., 1926. Rev. Appl. Mycol., vi (1927), 98.
- (31) WADHAM, S. M. : New Phytologist, xxiv (1925), 50.
- (32) WESTERDIJK, J. : Professor Johanna Westerdijk, Baarn, Holland, in correspondence (1927).
- (33) YOUNG, ARTHUR : A Tour in Ireland, 1780.

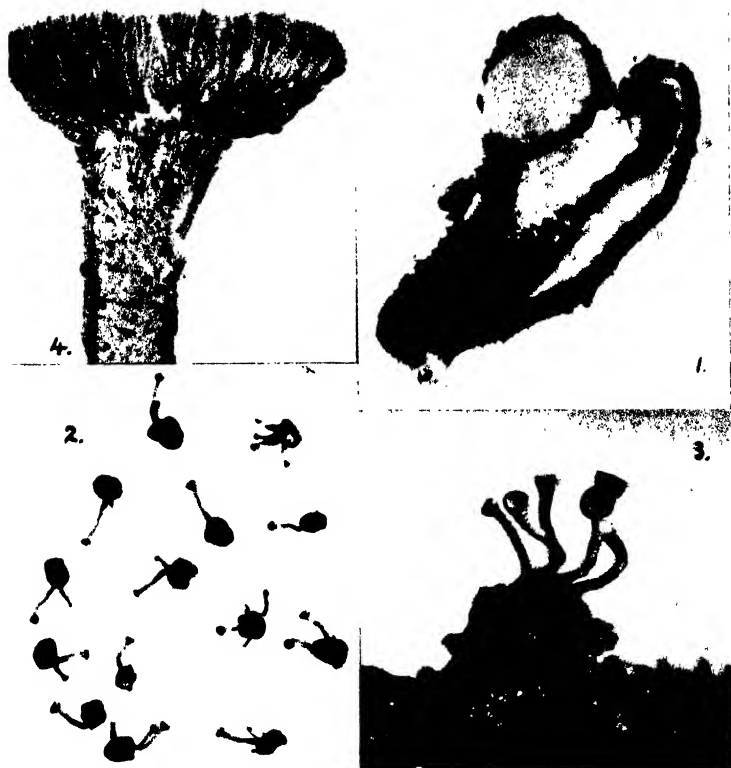


FIG. 1.—Seed in section showing sclerotium formed on surface and internal mycelium. ($\times 60$)

FIG. 2.—Seed with young apothecia formed on sclerotia growing on the seed. ($\times 4$)

FIG. 3.—Apothecia growing from sclerotium obtained in culture (immature). ($\times 5$)

FIG. 4.—Apothecium in section showing asci and ascospores. ($\times 20$)

Thanks are due to Dr. Pethybridge for fig. 2, and to Mr. W. Blake for figs. 1, 3, 4, and to Miss Stott for section 4.

INJECTION EXPERIMENTS ON TREES. By R. J. D. GRAHAM
and L. B. STEWART.

(Read 19th April 1928.)

These experiments, started in 1921, are still being continued as opportunity offers at the Royal Botanic Garden, Edinburgh.

The results so far obtained differ widely from those observed elsewhere (1), and this is the justification for recording results while the experiments are still proceeding.

Gramme molecular solutions of copper sulphate were used. The solution was introduced into the tree through a horizontally placed auger hole about 3 feet from the ground-level. The diameter of the auger was 1 inch, the depth of the hole varied from 2 to 6 inches according to the size of the subject. A wooden plug traversed by a metal pipe was driven tightly into the hole. The solution passed from a container by a 4-foot length of rubber tubing connected to the metal pipe. The apparatus was first tested with water which was replaced by the solution. The supply of solution in the container was renewed when necessary, fluid always being maintained in the apparatus throughout the experiment. The injections were carried out between May and July.

The path of the injected solution was traced by the penetration of the wood as seen in section. The solution passed upwards and also downwards into the roots (2). Treatment with a 3 per cent. solution of potassium ferrocyanide gave excellent results in defining the areas penetrated.

During the course of the experiments it was noted that the first traces of injury to the leaves occurred within forty-eight hours at latest from the commencement of the injection. The first leaves to be injured were on the first branch diametrically opposite the point of injection. Thereafter the crown of the tree was affected. A peculiar point was that the branch immediately above the first one affected escaped injury. The area of the crown to be first affected varied considerably, being sometimes the north side and sometimes the south.

The quantity of solution injected varied with the size of the tree, eighteen or more gallons being absorbed during the course of the experiments, which generally lasted a week. Little

difference was noted between the intake by day and by night. After the shrivelling of the leaves, fluid—solution or water—continued to be absorbed rapidly, the intake being greater at night, and much greater on the approach of showery weather.

Subject.	Age.	Annual Rings penetrated.
<i>Salix alba</i>	30	15-30 uniformly.
<i>Fagus sylvestris</i> (1) . . .	79	10-30 uniformly. 69-79 patches.
„ „ (2)	61	23-33 uniformly for $\frac{2}{3}$ of circumference. 36-45 uniformly for $\frac{1}{4}$ of circumference on opposite side from last. 53-61 uniformly for $\frac{2}{3}$ of circumference, overlapping the last two.
<i>Ulmus campestris</i> (1) . . .	86	40-86 uniformly, heavier in outer wood.
„ „ (2)	79	43-79 uniformly.
<i>Acer pseudo-platanus</i> . . .	69	25-59 uniformly for $\frac{3}{4}$ of circumference. 63-69 two small patches.
<i>Tilia europaea</i>	30	1-30 localised around auger hole.
<i>Pyrus Malus</i>	21	1-11 opposed to above area. 6-21 uniformly.

The injured specimens were not killed outright. In the injected *Acer* and in an *Aesculus* rapid development of dormant buds gave rise to new leaves.

REFERENCES.

- (1) YENDO, Y. : Journ. College of Science, Tokyo, xxxviii (1927).
MÜLLER, A. : Innere Therapie der Pflanzen. Berlin (1926).
PETRI, L. : Boll. d. R. Staz. di Patologia Vegetale, N.S., vii (1927).
- (2) EWART, A. J. : Proc. Royal Soc. Victoria, N.S., xxv (1912).

ON THE OCCURRENCE OF SCHIZOCOTYLY IN CERTAIN RANUNCULACEOUS SEEDLINGS. By ELIZABETH W. MILLER, B.Sc.

(Read 17th May 1928.)

Material.—The seeds of various Ranunculaceous genera were sown in soil in ordinary four-inch pots about the middle of November. The cotyledons appeared above ground in from thirteen to twenty-one days according to the genus, and at the end of the month the first seedlings were removed and fixed in a fluid of the following composition :—

Absolute alcohol	6 c.c.
Formalin	3 c.c.
Glacial acetic acid	1 c.c.

The occurrence of seedlings with three cotyledons was noticed in the sowings of *Delphinium cashmirianum*, *Thalictrum minus*, and *Nigella damascena*, while all the other species had normal seedlings. Only one tricotyledonous specimen was found in each of the *Thalictrum* and *Nigella* sowings, but about 25 per cent. of the *Delphinium* seedlings were abnormal, and of these some were fixed at intervals as they attained sufficient size, while the rest were left in order to watch the subsequent development. Unfortunately, probably owing to the cold and to overcrowding, the latter withered before the first foliage leaves appeared.

Method.—The seedlings were embedded in paraffin, and the sections (10 μ thick) were stained with the gentian-violet-light-green combination, which showed good differentiation in spite of the small amount of lignified tissue present in such young stages.

Delphinium cashmirianum.

Lubbock (9) has described the external features of several species of *Delphinium*, including *D. Staphysagria*, *D. elatum*, *D. hybridum*, *D. cardinale*, *D. nudicaule*, *D. consolida*, and *D. Ajacis*. Work has been done on the germination of *Delphinium* by Dickson (4). Lenfant (8) studied four species anatomically, namely, *D. Ajacis*, *D. consolida*, *D. Staphysagria*, and *D. elatum*,

and to these Sterckx (11) added *D. nudicaule*, while *D. luzulinum* and *D. formosum* were investigated by Miss Thomas (12). Both Lubbock and Lenfant report the occurrence of schizocotely in varying degree in *D. Ajacis*.

Delphinium cashmirianum possesses features similar to other species of the genus, but for purposes of comparison the struc-

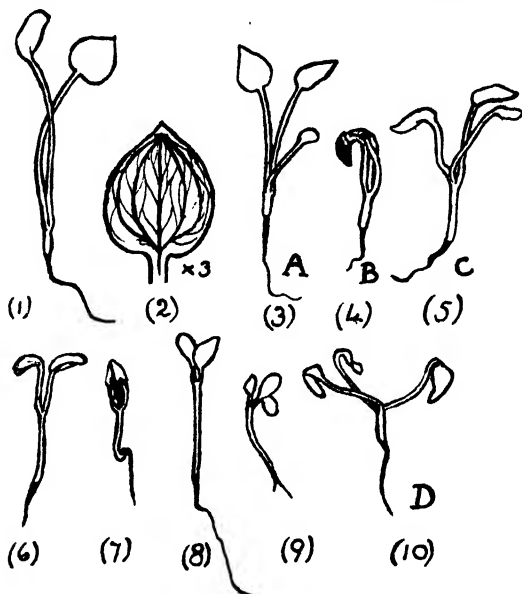


FIG. 1.—Seedlings of *Delphinium cashmirianum*, *Thalictrum minus*, and *Nigella damascena*. (1) Normal *Delphinium*. (2) Cotyledon of normal *Delphinium* to show veining. (3), (4), (5), and (10) Tricotyledonous *Delphiniums*. (6) Normal *Thalictrum*. (7) Tricotyledonous *Thalictrum*. (8) Normal *Nigella*. (9) Tricotyledonous *Nigella*. (All nat. size, except (2).)

ture of the normal seedling will be briefly described here. For convenience it is described from above downwards.

Fig. 1 (1) and (2) show the form of the seedling and the veining of the cotyledon; this veining was constant (as far as could be seen) for the tricotyledonous specimens also. Three vascular bundles enter the petiole from the lamina, and coalesce at the base of the lamina to form one strand. Very soon this strand takes on the typical Ranunculaceous "double-bundle" arrangement, each double bundle consisting of one protoxylem, and, diverging from this, two groups of metaxylem each capped with a group of phloem elements. This structure is main-

tained until the cotyledon tube is reached—in this species the petioles of the cotyledons are concrescent for a considerable distance above the cotyledonary node, but the tube is short compared to that in *D. nudicaule*, and does not obstruct the exit of the plumule as in that species.

The transition belongs to Van Tieghem's third type (13). As is so common in cotyledons and early foliage leaves, there is marked asymmetry in the entry of the cotyledon traces, one coming in later and more obliquely than the other. The transition is high, as is the rule for slender seedlings, and the diarch structure characteristic of the root is attained quite near the top of the hypocotyl, although the pericycle and endodermis do not become clearly defined until the external collet is reached. In seedlings with a high transition it is clear that the internal collet is quite independent of the external collet, as Sterckx explains so carefully. Plumular xylem elements make their first appearance just below the top of the hypocotyl, midway between the protoxylem poles. Few at first, they increase in number to a maximum when a complete xylem plate crosses the centre of the stele, then they decrease and finally disappear, leaving the poles quite separate again.

The first abnormal seedling (A) to be examined was one which had grown fairly large, and two of its cotyledons were the same size, while the third was little more than half their length, its lamina being proportionately small (fig. 1 (3)). Sections showed its anatomy to be as follows. One of the large cotyledons (*b*) was normal, and had a double bundle near the top of its petiole; the other (*a*) had a single bundle slightly larger than half a "double" one; the small cotyledon (*c*) had a single bundle of about the same size as that of (*a*). The petioles of (*a*) and (*b*) joined by one edge considerably above the hypocotyl—this corresponds to the beginning of the cotyledon tube in the normal seedling. The petiole of (*c*) approached slowly at first, then came in at an angle of about 60° (so that the bundle was cut obliquely), and gradually joined up with the free edges of (*a*) and (*b*). When the angle of entry became more acute, it was seen that the bundle of (*b*) was the first to become double, (*c*) divided next, and (*a*) was the last to divide (fig. 2 (1)). At the stem-apex the petioles of (*a*) and (*c*) together equalled in breadth the petiole of (*b*), and the junction of (*a*) and (*c*) gradually disappeared

so that one cotyledon petiole was formed having two bundles, each a double one, and an unequally bilobed exterior.

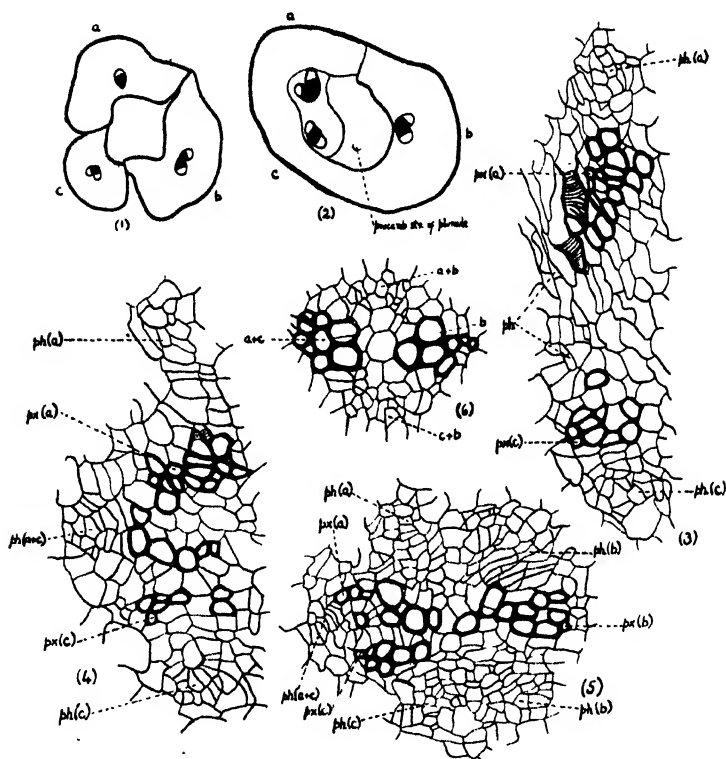


FIG. 2.—Tricotyledonous *Delphinium* (A). Letters denote bundles. (1) Semi-diagram of cotyledon tube; (a) has not divided, (b) and (c) are double, the division of (c) being later than that of (b). $\times 35$. (2) Semi-diagram of cotyledonary node; bundle of (c) approaches that of (a), and the half-bundles are rotating; plumular procambium is present. $\times 35$. (3) and (4) show convergence of bundles (a) and (c); the neighbouring half-phloems of (a) and (c) are not clear in (3), because (a) goes in towards axis at an angle; they are clear in (4), having joined and been pushed outwards by the convergence of xylems (a) and (c); rotations not complete. (3) $\times 270$. (4) $\times 300$. (5) Asymmetrically triarch; rotation of xylem not complete; (c) approaching (a); phloem (a+c) becoming squashed out; main phloem groups not yet joined. $\times 270$. (6) Diarch, but xylem (a+c) is bulkier than xylem (b). $\times 300$. (Xylem, black; phloem, outlined. px=protoxylem; mx=metaxylem; ph=phloem.)

Fig. 2 shows the structure in the hypocotyl. Applying the letters for the cotyledons to their respective bundles, (c) approached (a) fairly quickly, and at the same time all the

bundles rotated normally. The phloems from the neighbouring halves of (*a*) and (*c*) joined and were pushed outwards, the remaining phloems behaving normally and joining with the corresponding halves of (*b*). For a short distance ($450\ \mu$) an asymmetric triarch stele existed, and plumular xylem and procambium were present at this stage. As the xylem of (*c*) approached that of (*a*), the phloem between them (always smaller in quantity than the other two phloem groups) became obliterated, and finally about one-third down the hypocotyl the stele became diarch. The remainder of the hypocotyl was normal in structure, save that the xylem patch, which consisted of (*a*) and (*c*), was bulkier than the other, and this was found throughout the root as well.

The second seedling (B) was very young, and its cotyledons were still recurved and enclosed in the testa of the seed (fig. 1 (4)). Two of the cotyledon petioles were joined fairly far up, but the third was free until near the cotyledonary node; in section all three were much about the same size until the cotyledon tube was formed, when (*a*) and (*b*) decreased in size until together they were equal to (*c*), giving the appearance of two petioles, one of which had two double bundles (fig. 3 (1) and (2)); (*b*) was the last bundle to become double. Fig. 3 (3) and (4) show how (*b*) approaches (*a*). Their union resembles what took place in seedling (A), an asymmetric triarch structure being achieved, which lasted throughout the hypocotyl. Plumular procambium was present in quantity, as well as a few xylem vessels belonging to the plumular system, and these retarded the junction of the cotyledon phloems (*b*) and (*c*). At the base of the hypocotyl (*a*) and (*b*) began to rotate towards one another, and the intermediate phloem was obliterated, giving a diarch structure in the true root. At first the pole (*a*+*b*) was bulkier than (*c*), but further down the root this difference disappeared.

Had this seedling been a little older, it is possible that the cotyledons (*a*) and (*b*) would have separated, and that there would have been very little difference in the size of the cotyledons; although (*b*) might possibly have been a little smaller.

The third seedling (C) had a long hypocotyl, and three cotyledons of equal size (fig. 1 (5)). This seedling was halved for purposes of embedding, and unfortunately the upper half

showing the transition was lost. The part which remained, however, belonging to the base of the hypocotyl and the root,

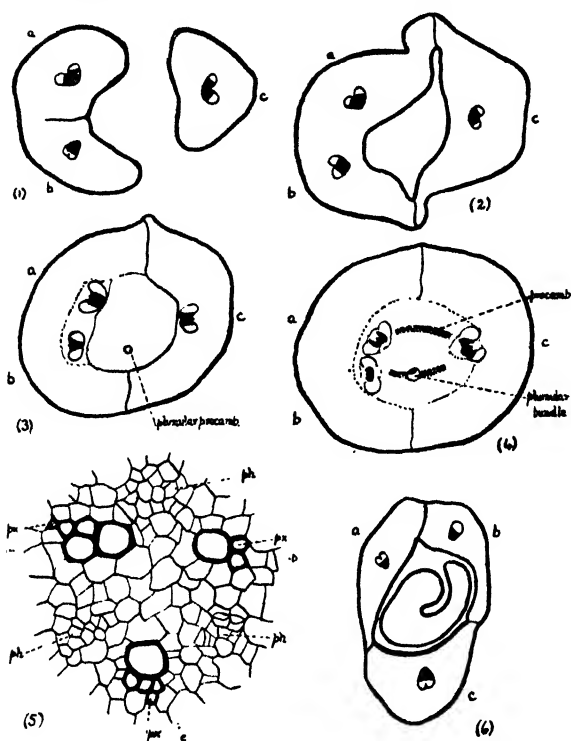


FIG. 3.—(1) to (4) Tricotyledonous *Delphinium* (B). (1) Semi-diagram of cotyledon petioles; petioles (a) and (b) have joined; note late division of bundles in (b). $\times 35$. (2) Semi-diagram of cotyledon tube; all bundles are double; join between petioles (a) and (b) not visible. $\times 40$. (3) Semi-diagram of cotyledonary node; protoxylem becoming exarch, (b) approaching (a); plumular procambium present. $\times 35$. (4) Semi-diagram of just below cotyledonary node; bundles come in at an angle, and therefore appear longitudinal; phloem ill-defined; much procambium present as well as a plumular bundle; (a) and (b) almost joined; rotation advancing. $\times 40$. (5) Tricotyledonous *Delphinium* (C). Structure at collet—similar throughout root; symmetrically triarch. $\times 270$. (6) Tricotyledonous *Delphinium* (D). Semi-diagram of cotyledon tube at stem-apex; originally all three petioles were equal, but (a) and (b) are now smaller; bundle (c) is the first to become double, then (a); (b) is still single; petioles (a) and (b) join before joining (c). $\times 35$.

showed a very symmetrical triarch stele which gave no signs of reduction to diarchy in the root. Fig. 3 (5) shows one of the xylem groups (a) slightly larger than the others, and (a)

and (b) have a slight tendency to point towards one another, but this was not so marked in the root.

A fourth seedling (D) was taken at a later date (fig. 1 (10)). The three cotyledons were of the same size, and externally, therefore, (C) and (D) were alike. Sections showed that at first the petioles were equal in size, but, about half-way between the lamina and the cotyledonary node, two, (a) and (b), approached one another, and (c) was much larger than (a) or (b). Just above the stem-apex (a) and (b) joined by one edge, and at this stage none of the bundles were double. Fig. 3 (6) shows the structure of the cotyledonary tube at the stem-apex; (c) was the first to have a double bundle, then (a), and (b) was the last to divide. This was the case in all the abnormal *Delphinium* seedlings—the first cotyledonary bundle to become double belonged to the normal cotyledon, but there was no such regularity in the order of division of the other two. In seedlings (A) and (B), the cotyledon with the smaller vascular supply was the next to have a double bundle, but in (D) the corresponding cotyledonary bundle was the last to divide. The vascular structure in the hypocotyl resembled to a certain extent that in the first two seedlings, but it was complicated by the presence of much plumular xylem. The bundles (a) and (b) approached one another fairly quickly, at the same time approaching the centre of the stele, but (c) lagged considerably in its approach to the centre. The structure in the hypocotyl was asymmetrically triarch at first, becoming more symmetrical towards the base, and xylems (a) and (b) joined and parted again more than once. Pole (c) was the largest, but as it decreased in size it joined with the other two, to give a continuous xylem plate for a while. Then (c) separated again, and the phloem between (a) and (b) became smaller, remaining thus till the collet. At the top of the root (a) and (b) began to converge, and a diarch structure slowly appeared. This transition to diarchy was late in appearing, not taking place until some distance below the collet.

Since the above investigations were made, some seedlings grown from Sutton's Mixed Annual Larkspur seeds have been found showing all stages of schizocotyly to true tetracotyly. These are of interest, since in previous cases of schizocotyly a complete series of stages to tetracotyly has usually been found. It has not yet been possible to examine

the anatomy of these seedlings, but it is hoped that this will be done soon.

Thalictrum minus.

The external features of this species were described by Lubbock (9), while Sterckx (11) and Mansion (10) give anatomical details for this and other species. Four other species of *Thalictrum* are dealt with by Miss Thomas (12).

The normal seedling is remarkable for the late division of the cotyledon bundle as compared with *Delphinium*. There is no cotyledon tube, and there is no sign of double bundles until the cotyledonary node is reached. The seedling examined was not very old (fig. 1 (6)), but the stem bundles had already made their appearance, due to the fact that in *Thalictrum* the first foliage leaves appear very early. The transition is high, being completed very soon after the cotyledonary node, and as usual one bundle completes its rotation before the other. The hypocotyl is long, and for three-quarters of its length has the vascular structure typical of a diarch root (fig. 4 (1) and (2)).

The tricotyledonous seedling was very young, the cotyledons being still enclosed in the seed testa, but their petioles were free (fig. 1 (7)). Fig. 4 (3) to (6) show the structure of the cotyledons down to the cotyledonary node. In the testa, (b) had the largest number of procambial strands, therefore it is probable that this was the oldest cotyledon; likewise (b) was the first to show the convergence of all the bundles to form one main central strand. Subsequent sections, however, showed that (c) was the extra cotyledon, and at the stem-apex (c) had the smallest petiole. Division of the bundles was later than in the normal seedling, there being no sign of double bundles at the cotyledonary node; (a) was the first to become double, thus corresponding to the abnormal *Delphiniums*. All the bundles came in very obliquely, and the union of (b) and (c) was not clear. The phloem between them was slight and quickly obliterated, and the triarch appearance was asymmetrical and of short duration. It was noticeable that (a), the normal cotyledon, had completed its transition early, in marked contrast to the abnormal *Delphiniums*, where the corresponding bundle was the last to complete its rotation. Phloems (b) and (a) had joined for some considerable time

before phloems (*c*) and (*a*), the union of the latter taking place about half-way down the hypocotyl, when the normal diarch structure was completed. No further changes occurred in the

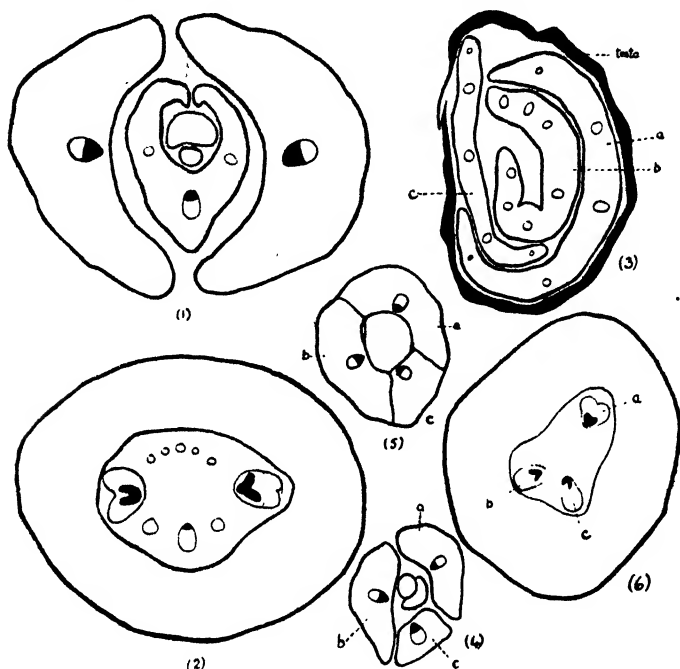


FIG. 4.—(1) and (2) Normal *Thalicttrum minus*. Diagrams from camera lucida drawings. (1) Stem-apex and cotyledon petioles; all bundles single. $\times 35$. (2) Just below cotyledonary node; bundles beginning to split—oblique due to angle of entry; plumular bundles present. $\times 35$. (3) to (6) Tricotyledonous *Thalicttrum*. (3) Cotyledons in testa; (*b*) has the largest number of procambial strands. $\times 35$. (4) Stem-apex—single bundles. $\times 35$. (5) Cotyledonary node. $\times 40$. (6) Bundles (*b*) and (*c*) converging, beginning to divide, oblique. $\times 60$.

passage to the root, save the normal changes at the external collet.

Nigella damascena.

The external appearance of this and other *Nigella* species has been dealt with by Lubbock (9). The seedling anatomy of this and other *Nigella* species has been studied by Miss Thomas (12), and has also been most fully described by Sterckx (11), since he used it as his type for the Ranunculaceous seedlings; but Sterckx rejects the theory of xylem

rotation from the stem to the root position (*i.e.* centrifugal to centripetal), and describes the structure in connection with his theory of contacts between the xylems of the root, the cotyledons, and the stem. As the seedlings described above have been treated from the standpoint of the rotation theory, it will be as well to deal briefly with *Nigella* also from this standpoint.

The normal seedling (fig. 1 (8)) had the lamina of its cotyledons removed previous to embedding, but sections showed that even near the top of the petioles the bundles are typically double—even more so than in *Delphinium*. There is a fairly long cotyledon tube, and, although the transition is high, it is slower in beginning than in *Delphinium*. For some distance below the cotyledonary node ($250\ \mu$) the bundles show little sign of rotation; they approach the centre of the stele slowly, and well-defined stem bundles make their appearance, as usual one being more advanced than the other, and having the effect of retarding the union of the phloems on that side (or rather perhaps it forces them apart); diarchy is achieved one-third of the way down the hypocotyl. Much plumular xylem complicates the structure, but when it vanishes the two poles are left separate.

In the schizocotylous specimen, as can be seen from fig. 1 (9), one cotyledon was small and separate, while the other had a united petiole but two laminae. As before, the laminae were removed prior to embedding, but it would have been better had this not been done; for the first sections showed only two petioles (as was to be expected), and each contained only one double bundle. Therefore the vascular systems of the two halves of the bifid cotyledon must have united very early. One (the "double") petiole was larger than the other at first, and grooved on its inner side; but it very soon became the same size as the other, and by the time the cotyledon tube was reached there was no difference between them. The bundles of the "double" petiole were perhaps slightly larger than the others; they contained more xylem but less phloem. They, too, soon became of normal size, and the rest of the seedling resembled the normal seedling except for the smaller development of plumular xylem in the hypocotyl, since it was a younger seedling. The larger amount of xylem in the "double" petiole is doubtless due to the larger size of the

cotyledon it has to supply, and the smaller amount of phloem suggests that, although the bifid cotyledon must have been manufacturing more food substances than the normal cotyledon, it must have been using up a greater proportion, and so there would be less to store. The food manufactured by the cotyledon would be the source of energy for the greater number of cell divisions, resulting in the bigger lamina.

DISCUSSION.

The occurrence of schizocotyly in Angiospermous seedlings has long been known, and there have been numerous cases mentioned by various writers, but the anatomical study of such seedlings has been neglected until recent years. R. H. Compton (2) gives a list of previous cases mentioned, at the beginning of his paper on "Syncotyly and Schizocotyly." According to him, true polycotyly, except for its presence in the Gymnosperms, is rare, and in the Angiosperms is found only in *Persoonia* (Proteaceae), *Nuytsia*, and *Loranthus* (Loranthaceae); other examples are now known to be the result of greater or less division of the cotyledons. Miss Thomas (12), however, describes *Pittosporum crassifolium* as a true polycotyledon, having four cotyledons, although tricotyledonous seedlings have also been found. This writer reports a few other occurrences of schizocotyls in the Cruciferae.

Holden and Bexon (6) have described the structure of polycotylous seedlings of *Cheiranthus cheiri*, and from their work conclude that cotyledon increase may arise either by cotyledon fission, by dichotomy of the growing point of the cotyledon, or (more doubtfully) by downward displacement of one or more epicotyledonary leaves.

Miss Bexon (1) further investigated the anatomy of some schizocotylous seedlings of *Centranthus ruber*, and reached the same conclusions as Hill and de Fraine (see below).

Lee (7), in his paper on the Compositae, mentions several stages of schizocotyly in *Dimorphotheca pluvialis*, where the extra cotyledon in the tricotyls is undoubtedly derived by fission.

M. Lenfant (8), as already mentioned, found all stages of schizocotyly in *Delphinium Ajacis*.

Hill and de Fraine (5), in connection with their work on Gymnosperm seedlings, have classified cotyledons thus, "on the first organisation of root structure, whether it appears high or low in the hypocotyl" :

- (1) Vascular structure of cotyledon gives rise to one pole of root structure—Whole cotyledon.
- (2) Vascular bundles of two adjacent cotyledons give rise to one pole of root structure—Half cotyledon.
- (3) Trace of seed-leaf plays no part in transition phenomena, but joins on to any adjacent vascular tissue in no definite fashion—Subsidiary cotyledon.

The boundary between a whole and a half cotyledon is, however, not well defined, and there is a constant succession of stages between the two. The species studied above are a good example of this. The *Nigella* seedling was at the most elementary stage; the lamina of one cotyledon was deeply bifid, and this had only a slight effect on the vascular system. The *Thalictrum* seedling was at the next stage of vascular structure, consisting of one whole and two half cotyledons; the extra strand very quickly joined with that which supplied the other half cotyledon, and the intermediate phloem was not distinct, although the xylem was triarch for a short distance.

The *Delphinium* seedling (A) showed the next stage; the cotyledons were obviously asymmetrical, and this resulted in an asymmetrical triarch stele which reverted to diarchy a third of the way down the hypocotyl. This seedling might be considered as having three "whole cotyledons" if judged by the definition given above, but one was so much smaller than the other two that this seems incorrect.

In seedling (B) the cotyledons were of more equal size, but the petioles of two were joined for some distance. Asymmetrical triarchy lasted throughout the hypocotyl, diarch structure appearing at the collet. Here again the "half cotyledons" are almost "whole cotyledons."

Seedling (D) appeared to have three equal cotyledons, and the transition from a more symmetrical triarchy to diarchy occurred some distance below the collet.

Seedling (C) was symmetrically triarch throughout, and with (D) may be considered as a true tricotyl having three "whole cotyledons."

As Hill and de Fraine point out, reduction in the number of root poles frequently occurs in true polycotyls, diarchy being the final result, and for this reason they base their classification upon the first root structure which appears. On the other hand, Compton sees in the level of the change to diarchy an indication of the degree of division in the cotyledon. "Fission of the cotyledon leads to fission of the corresponding root pole, or its connection at a higher or lower level in the axis according to the degree of splitting."

That the number of leaves does have power to influence the vascular structure of the roots has been proved by Chauveaud (1921), when he found that the production of new leaves is accompanied by a differentiation of new conducting elements in stem and root. Dauphiné (3) reduced the number of leaves of a *Lupin* seedling by removing some, and found that there was a corresponding absence of certain more or less important vascular elements in the root. These facts show that the vascular system is undoubtedly plastic, at least in the young stages. Another writer states that "schizocotyly is associated with a vascular acceleration which is very marked at the base of the cotyledon and the apex of the hypocotyl."

It does not seem possible to say what determines the appearance of schizocotyly. Since, so far as is known, it is not heritable, it is most probably due to external influences working on the cotyledons at a very young stage—perhaps some factor in the endosperm—or to some internal physiological disturbance; and these factors seem to be more prominent in some species than in others. It is evidently not the result of vascular splitting; the *Nigella* petiole bundles, and Dauphiné's and Chauveaud's experiments, prove that the vascular supply arises in response to the growth of the leaf—at any rate to begin with, although the future size of the leaf may possibly depend on the size of the vascular strand supplying it. The vascular structure rather lags behind the degree of splitting of the cotyledons, as can be seen in *Delphinium* seedling (D)—this outwardly resembles (C) in possessing three equal cotyledons, but whereas in (C) the whole root is triarch, in (D) there is a reduction in the root to diarchy.

The vascular supply of the extra cotyledon arises independently of any other vascular supply, the xylem probably being the earlier developed (as in the *Nigella* petiole), and is the

direct consequence of the division of the original normal cotyledon. The character of the stele of the root depends on the amount of vascular tissue evoked by the new cotyledon, and also on the time of division of the original cotyledon. If the cotyledon is late in dividing, the main vascular supply for the cotyledon will be in existence, and the new vascular strand will have neither time nor room to develop properly; therefore it will very soon join on to that already present, *i.e.* triarchy will very soon give way to diarchy. If, however, the division occurs early, then all three cotyledons will start approximately together, and their vascular supplies will have equal chances, when symmetrical triarchy will result as in *Delphinium* (C). Therefore the vascular phenomenon is essentially a contact of the new strand with the old strand, and not a splitting of the older strand or root pole to supply the new cotyledon. This is, perhaps, more readily seen if the structure is followed from above downwards, when the obliteration of the intervening phloem is apparent.

These examples of schizocotily are of interest from another point of view, namely, the relative antiquity of polycotily, dicotily, and monocotily, since they form an intermediate stage between the first two. True polycotily is heritable, while schizocotily (so far as is known) is not; but it is possible that in Angiosperms dicotily is the more primitive, and schizocotily is therefore "an instructive parallel in the course of evolution of polycotily" (Compton). Schizocotily would thus have become fixed as polycotily in the course of time. This does not necessarily imply that polycotily in the Gymnosperms arose in the same way. If polycotily is primitive and dicotily derived, then the cases of schizocotily are interesting reversions to an ancestral condition. Monocotily is a step further in this sequence, and may have arisen from dicotily by fusion (syncotily), which is more likely than that dicotily arose from monocotily by fission (schizocotily).

SUMMARY.

1. The anatomy of certain Ranunculaceous seedlings with three cotyledons was examined, and it was found that all stages of schizocotily, including complete tricotily, were represented.

2. An unusually large proportion of such seedlings was found in a sowing of *Delphinium cashmirianum*.

3. In one case at least the vascular structure lagged behind the division of the cotyledons, and a symmetrical tricotyledonous seedling had a diarch root.

4. The extra vascular elements are invoked by the division of the cotyledon, the reason for such division being unknown.

5. According to the time and degree of fission of the cotyledon, there are three possibilities for the behaviour of the new vascular tissue of the extra cotyledon: (1) It may unite with the vascular strand of the other part of the cotyledon above the internal collet; (2) it may make contact with the corresponding pre-existing root pole (below the internal collet); or (3) it may itself form a new root pole, as happens when the fission is very early. It is not correct to describe the corresponding vascular root pole as dividing to supply the two half cotyledons.

6. Once a cotyledon has divided, the further growth of the extra cotyledon depends on the number of vascular elements formed in response to this division. If few are formed, the cotyledon remains undersized; if many, it is normal in size.

7. Schizocotyly stands midway between dicotyly and polycotyly, and as in the Angiosperms the primitive structure is probably dicotyly, schizocotyly represents the course of evolution from dicotyly to polycotyly.

The work in connection with this research was carried out in the Botany Department of University College, Dundee (St. Andrews University), and I would take this opportunity of expressing my sincere thanks to Dr. Edith Philip Smith for her unfailing interest in the work and for her helpful criticism at all times.

REFERENCES.

- (1) BEXON, DOROTHY (1920): Observations on the Anatomy of Teratological Seedlings. II. Some Polycotylous Seedlings of *Centranthus ruber*. Ann. Bot., xxxiv.
- (2) COMPTON, R. H. (1913): Anatomical Study of Syncotyly and Schizocotyly. Ann. Bot., xxvii.
- (3) DAUPHINÉ, ANDRÉ (1925): The Experimental Demonstration of Vascular Inter-relationship between Leaf and Root. Compt. Rend. Acad. Sci. Paris, clxxxi. (Reference taken from Botanical Abstracts.)
- (4) DICKSON, A. (1872): Germination of *Delphinium*. Journ. Bot., x.

- (5) HILL and DE FRAINE (1914): The Classification of Seed-leaves. Ann. Bot., xxviii.
- (6) HOLDEN, H. S., and BEXON, D. (1918): Observations on the Anatomy of Teratological Seedlings. I. The Anatomy of Polycotylous Seedlings of *Cheiranthus cheiri*. Ann. Bot., xxxii.
- (7) LEE, E. (1914): Observations on the Seedling Anatomy of certain Sympetalae. II. Compositae. Ann. Bot., xxviii.
- (8) LENFANT, C. (1896): Contribution à l'anatomie des Rénonculacées. Le genre *Delphinium*. Mém. Soc. Roy. des Sc. Liège, 2^{me} sér., xix.
- (9) LUBBOCK, Sir J. (1892): On Seedlings.
- (10) MANSION, A. (1897): Contribution à l'anatomie des Rénonculacées. Le genre *Thalictrum*. Mém. Soc. Roy. des Sc. Liège, 2^{me} sér., xx.
- (11) STERCKX, R. (1900): Recherches anatomiques sur l'embryon et les plantules dans la famille des Rénonculacées. Mém. Soc. Roy. des Sc. Liège, 3^{me} sér., ii.
- (12) THOMAS, E. N. (1914): Seedling Anatomy of Ranales, Rhoeadales, and Rosales. Ann. Bot., xxviii.
- (13) VAN TIEGHEM, PH. (1891): Traité de Botanique.

LIGHT RECEPTORS IN MESEMBRYANTHEMUM.

By CHRISSY I. KEAN, B.Sc.

(Read 21st June 1928.)

A noteworthy feature of the leaves of many species of *Mesembryanthemum* is the occurrence on the surface of circular translucent spots which are due to colourless areas underneath the epidermis. In leaves where these spots are not present there are, in many cases, epidermal hairs of various types. Although not at first obvious, it will be seen that the development of the former and absence of the latter are inter-related.

The species may be divided into two types: (1) where there is a layer of very small crystals of calcium oxalate in the outer wall of the epidermis, and (2) where no crystal layer is formed. *M. infllexa* is of the former type and is also characterised by having translucent spots uniformly distributed over both surfaces. Large, colourless cells, ovoid or biconvex in shape, occur throughout the mesophyll, separated from the epidermis usually by the outer palisade layer and from each other by the width of six chlorophyllous cells. These cells penetrate to the aqueous tissue which occupies the centre of the leaf and which is entirely surrounded by the mesophyll. The cell sap in these large cells is highly mucilaginous and contains a weak solution of tannin. They may therefore be called tannin sacs, and it is the absence of chloroplasts in these cells which gives the translucent appearance to the circular spots visible externally (fig. I (1)).

A slight variation occurs in *M. tigrinum*. The apical two-thirds of the leaf shows white circular areas, while the basal third shows translucent spots. The white spots mark the position of tannin sacs also, but the whiteness is due to the heaping up of the oxalate crystals in the outer epidermal wall at these areas. Frequently a single white spot covers two tannin sacs instead of one (fig. I (2)).

In these two species the epidermal cells have the same average size over the whole surface. The only noteworthy feature being that there are no stomata on the translucent areas. In *M. glomeratum* there are typical small, hexagonal,

epidermal cells intermixed with large, circular, protuberant cells. There is no crystal layer in the epidermis except in

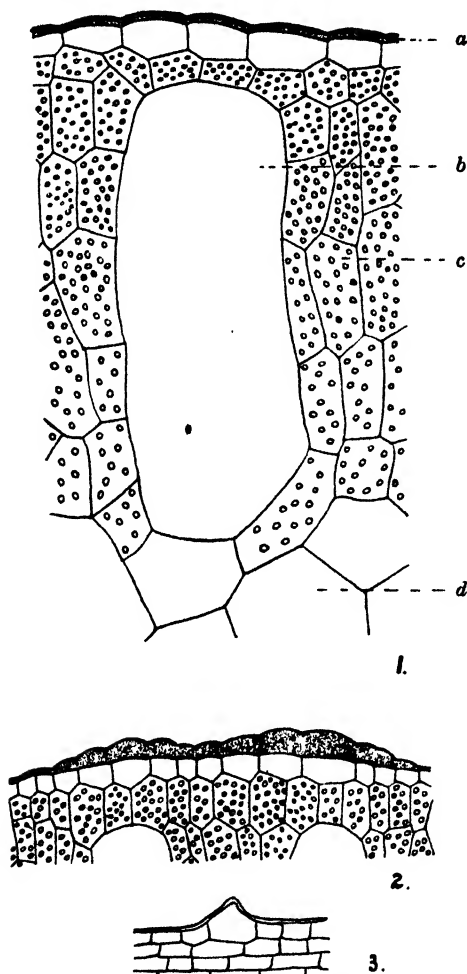


FIG. 1. 1. Transverse section of a leaf of *M. inflexa*, showing a large tannin sac: *a*, crystal layer; *b*, tannin sac; *c*, chlorophyllous tissue; *d*, aqueous tissue ($\times 160$). 2. Transverse section of leaf of *M. tigrinum*, showing the thick crystal layer over two tannin sacs ($\times 60$). 3. Part of hair of *M. tigrinum*, showing an ocellar epidermal cell ($\times 60$).

these large cells which are situated above the tannin sacs (fig. II (4 and 5)). In *M. verruculatum* the epidermis has the same characters as in *M. glomeratum*, except that the large

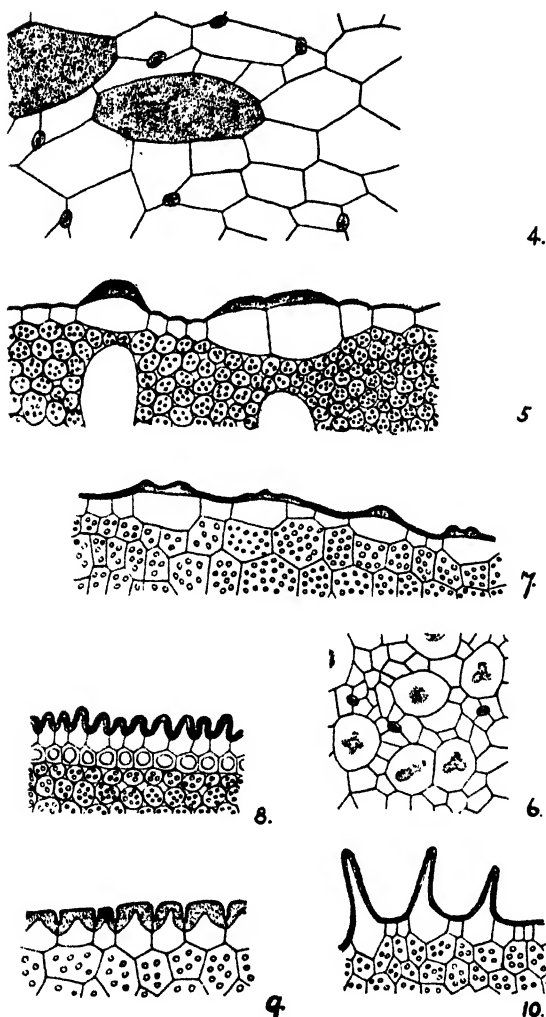


FIG. II. 4. Epidermis of *M. glomeratum*, showing normal cells with no crystals and large cells with a crystal layer. 5. Transverse section of leaf of *M. glomeratum*, with large epidermal cells above the tannin sacs. 6. Epidermis of *M. crassulinum*, showing one to four protuberances in the large epidermal cells. 7. Transverse section of leaf of *M. crassulinum*, showing epidermal protuberances. 8. Transverse section of leaf of *M. thunbergianum*, with projecting epidermal cells. 9. Transverse section of leaf of *M. lehmanni*. The crystal layer shows a "thin spot." 10. Transverse section of leaf of *M. Ecklonis*, showing epidermal hairs, each of which is ocellar. (All $\times 60$.)

cells are narrow and oval. In this species, however, there are no tannin sacs in the mesophyll.

An elaboration of this type occurs in *M. crassulinum*, but here there is a crystal layer over the whole outer wall, in large and small cells alike, but in the large cells are one to five protuberances caused by a thickening of the crystal layer at certain points (fig. II (6 and 7)). Here again there are no tannin sacs.

In *M. Thunbergianum* there is a complete crystal layer, and every cell is protuberant and almost conical (fig. II (8)). There are no tannin sacs in either this or the two following species. In *M. Lehmanni*, again, every cell is protuberant but the surface is flat, and the epidermal cells are rectangular in section but are partially separated from each other. The lumen in this case is conical since the crystal layer is very thick at the angles but shows a "thin spot" at the centre (fig. II (9)). *M. Ecklonis* has typical epidermal cells intermixed with larger cells, which are drawn out into a tapering hair (fig. II (10)).

These species all have either a complete or partial crystal layer in the epidermis. *M. cultratum* is an example of the type which has no crystal layer. The outer wall of the epidermis is quite flat and tannin sacs are numerous. *M. pugioniforme*, in comparison, has no tannin sacs, and the outer wall of the epidermal cells is convex.

The relation between crystals, hairs, and tannin sacs is not clear unless the function of the tannin sacs is known. They are designated by Dannemann (1) as "water cells" whose function is (a) storage of water, and (b) captation of light. The first he proves by allowing a leaf to wilt and finding that it shows protuberances caused by the water cells, and that therefore these cells lose water less easily than the assimilatory elements. He states that they occupy mainly the under-surface of the leaf, and on account of the oblique orientation, especially in the bud, are on the best-exposed surfaces and thus transmit light to the central tissue.

That they are water-storing cells is obvious, both from Dannemann's experiment and also by observing that when the plant is insufficiently watered or the temperature is low the protuberant areas become very evident. This may be explained by the fact that the cell sap is mucilaginous.

In only a few species are the translucent spots more numerous on the under-surface, and in these cases the leaves are horizontal or nearly so, and therefore are not in the best position for captation of light. That they have a marked relation to light is shown by Haberlandt's method (2). A strip of tissue, composed of epidermis and chlorenchyma only, was mounted over a moist chamber; a light spot was visible by reflected light, showing that the tannin sac acts as an ocellus. Several strips of tissue similar to the above were then placed with the outer surface uppermost on a piece of sensitised paper previously moistened with water, and then exposed to vertical illumination. After fixation the photograph showed dark spots marking the position of the tannin sacs.

The actual average dimensions of the tannin sacs in *M. inflexa* are $320\ \mu$ in depth and $120\ \mu$ in diameter, while the outer arc formed by the epidermis is $200\ \mu$ in diameter. The average diameter of the light spots is $150\ \mu$. Light must therefore be condensed at the epidermis and diffracted at the aqueous tissue. The focal point is therefore within the tannin sac. The convexity of the epidermis will give condensation, but there is diffraction at this point also, caused by the crystal layer in the epidermal wall. Consequently, the focal distance is lengthened as can be shown by experiment. A piece of thoroughly soaked epidermis was mounted over a small aperture in opaque, black paper, and light applied to the outer surface. The focal point was then determined and the image on the screen measured. A piece of epidermis from *M. pugioniforme*, in which the dimensions of the cells were the same as in *M. inflexa* but there was no crystal layer, was treated in the same way. A shorter focal length was obtained, and the diameter of the image was less by one-sixth. Haberlandt's method in the case of *M. cultratum*, which has a flat surface and no crystal layer, gave the following results:—

Average diameter of tannin sacs = $240\ \mu$.

„ „ „ light spots = $300\ \mu$.

These results compare with *M. inflexa* as follows:—

Average diameter of tannin sacs = $120\ \mu$.

„ „ „ light spots = $150\ \mu$.

The two sets of results are proportionate, and the inference is that the condensation caused by the curvature of the

epidermis and the diffraction caused by the crystal layer will roughly balance; the actual diffraction obtained in the photograph is therefore entirely due to the tannin sac.

An experiment was also performed to show that the spots actually affect the acidity of the aqueous tissue. *M. obconellum* was selected in this case on account of the large size and prominence of the translucent areas. The plant has only one pair of leaves, and in one of these the spots on the upper flat surface were blackened, while the sides of both leaves were completely blackened. After several days the aqueous tissue of the leaf in which the spots were darkened gave a P_h of 5.9 and the other 6.3, showing that light passes more easily to the aqueous tissue by means of the tannin sacs. The tannin itself has no effect on the light which passes through it. It is an inactive substance and has no effect on the spectrum.

The other species with special light receptors are all modifications of the *M. inflexa* type. In *M. tigrinum* the oxalate layer is most dense in the region of greatest illumination, i.e. towards the apex. In this case diffraction is still greater at the epidermis. On the marginal multicellular hairs in this species is an occasional conical ocellar cell (fig. I (3)). In *M. glomeratum* the crystal layer is only found in the region of the tannin sacs, and in *M. verruculatum* in epidermal cells which alone serve as receptors. The protuberances in the large cells of *M. crystallinum* are ocellar, and in *M. Thunbergianum* each epidermal cell is an ocellus. In *M. Lehmanni* the inner layer of the outer wall is the condenser, and in *M. Ecklonis* the hair acts as an ocellus and gives a definite though faint light spot at the aqueous tissue.

REFERENCES.

- (1) DANNEMANN: Beit. zur Kenntnis der Anat. und Ent. der Mesembryanthemum. Halle-Wittenberg. 1883.
- (2) HABERLANDT: Phys. Anat. Eng. Trans. (1914), pp. 617-618.

ARTIFICIAL CRYSTALS IN PRESERVED TISSUE OF MESEMBRYANTHEMUM. By CHRISSY I. KEAN, B.Sc. (With Pl. II.)

(Read 21st June 1928.)

It was observed that after immersion for about two weeks in 90 per cent. alcohol, crystals appeared in the aqueous tissue of the leaves. These were of two kinds, (1) aggregate sphaerocrystals composed of elongated, rectangular plates, some with truncated ends (fig. 1), and (2) cubic crystals (fig. 2). These crystals have been observed by various workers, but have not been identified in the *Mesembryanthemums*. A full account of similar crystals is given for *Angiopteris evecta* by Belzung and Poirault (1). It was suggested by earlier writers that as they are abundant in tissues deprived of starch (or almost so), they replace the carbohydrate. This is not so, for they occur in tissues both when starch is present or absent. Hansen (2) shows them to be salts of calcium which are soluble in water, but give a yellow precipitate with ammonium molybdate, and are therefore crystals of calcium phosphate.

Belzung and Poirault found that after several months in 90 per cent. alcohol, whitish corpuscles 0.2 to 0.6 mm. in diameter appeared on the natural and cut surfaces of the leaf of *Angiopteris*. These corpuscles were sphaerocrystals of prisms. They found further that four days were sufficient for these crystals to appear at the natural surface. The tests made by these workers were as follows :—

- (1) The crystals dissolved in cold water in ten minutes.
- (2) With H_2SO_4 they gave crystals of gypsum.
- (3) The addition of alcohol made a watery solution milky.
- (4) On burning, the material first blackened, then swelled considerably, giving a white residue.
- (5) They were insoluble in a saturated solution of neutral calcium malate, but soluble in acid calcium malate.

These tests prove the crystals to be of neutral calcium malate.

It should be remembered that in *Mesembryanthemum* species there are two kinds of crystals as already referred to. The sphaerocrystals measure 0.15 mm., appear after two weeks,

but do not exude at the cut surface. An attempt was made to obtain them by making longitudinal slits in the leaves and leaving them in alcohol which was allowed to evaporate slowly, but only minute crystals could be obtained in this way and not in sufficient quantity for examination. They were soluble with difficulty even in pure water, taking about a week to dissolve. This is probably due to the mucilage in which they are embedded. The cubic crystals obtained in the same way do not dissolve at all. Both give gypsum crystals with H_2SO_4 , the cubic crystals after a considerably longer time. Only after the cubic crystals had been broken down by H_2SO_4 was a yellow precipitate obtained with ammonium molybdate, and that in the region of the cubic crystals only. This test, along with the fact that they are insoluble in water, shows them to be crystals of calcium phosphate. From these results it seems as if Hansen, in pronouncing the soluble crystals as calcium phosphate, was getting the molybdate reaction from phosphates in solution, or else he failed to observe the difference between the two kinds of crystals.

The sphaerocrystals were tested *in situ* by β -naphthol sulphuric acid (3). The details of this test are reproduced in "Weston's Carbon Compounds," from the Chemical News, vol. lxxv, p. 1941. On treating a section in this way, a reaction took place, giving gypsum crystals and a greenish-yellow solution which turned to bright yellow on heating. On adding a drop of cold water, a red coloration was obtained. These colour tests show the crystals to be of calcium malate. They are always embedded in mucilage and this cannot be got rid of even in the extract. An extract was made, using the method of Hilger and Cross (4), and by recrystallising, crystals were obtained similar to those in the leaf but much larger (fig. 3). The same crystals were again obtained by the method described by Onslow (5), the former method, however, being the most satisfactory, since the crystals are precipitated by alcohol; and by the latter method, incomplete precipitation only allows of the crystals persisting to the end of the separation.

With the crystals so obtained, Belzung and Poirault's tests were confirmed.

- (1) The crystals were soluble though slowly.
- (2) They gave gypsum with H_2SO_4 .

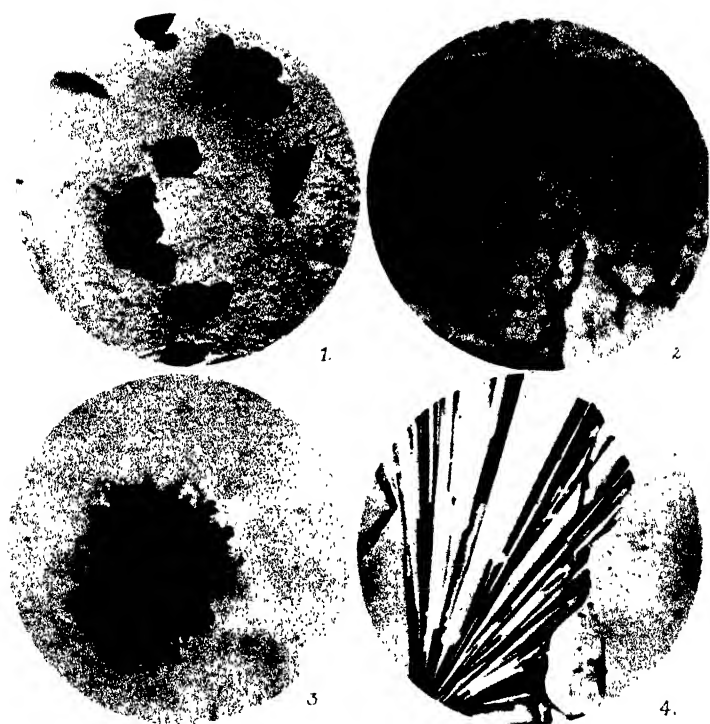


FIG. 1.—Sphaerocrystals of calcium malate in the leaf of *Mesembryanthemum* which has been preserved in alcohol. The preparation also shows raphides. ($\times 120$)

FIG. 2.—Cubic crystals of calcium phosphate in spirit material. ($\times 120$)

FIG. 3.—A large crystal of calcium malate obtained from an extract of the leaf tissue of *Mesembryanthemum*. ($\times 160$)

FIG. 4.—Crystals of calcium malate obtained by evaporating the leaf extract on a slide under a cover-glass. ($\times 50$)

- (3) On adding excess alcohol, the solution became milky.
- (4) Blackening and swelling occurred on burning.
- (5) Sufficient material was not available to show whether the crystals were soluble or not in calcium malate.

The crystals obtained in this way, in species showing less mucilage, instead of forming a sphere, became collected together in feather-like groups, and in as pure a state as possible were deliquescent.

Summarising the above results, it is found that the artificial crystals occurring in spirit material are of two kinds, namely, cubic crystals, and aggregate sphere crystals composed of flat prisms. The cubic crystals are insoluble in water and are of calcium phosphate; the sphere crystals are soluble in water and are of calcium malate.

REFERENCES.

- (1) BELZUNG AND POIRAULT : *Journal de Botanique* (1892), p. 286.
- (2) HANSEN : *Arbeiten des Bot. Inst. der Wurz.*, iii (1884-88), 102.
- (3) WESTON : *Carbon Compounds*, p. 31.
- (4) CZAPEK : *Biochemie*, ii, 443-4.
- (5) ONSLOW : *Plant Biochemistry*, p. 85.

NOTE ON A CIRCUMNUTATION RECORD.

By MARJORIE L. R. BOVELL, B.Sc.

(Read 21st June 1928.)

The experimental material was the shoot of *Melaleuca integrifolia*. Its growing region was 20 mm. long and its L.G.C. 0.00006, i.e. its growth-rate was very slow.

Darwin's glass-plate method was used, but records were taken at intervals of five and fifteen minutes respectively, instead of the longer periods of half-hour and hour and half described in the "Movements of Plants." Further, for a period of seven hours of a twenty-four hours' record the moving tip was continuously watched and its path plotted on freehand graphs.

The experiment was carried on in the Experimental Greenhouse, and automatic thermograph records were taken throughout the period of experiment. The following records were taken :—

1. A continuous record for twenty-four hours from 3.45 p.m. on 14th June through the night to the same hour on the 15th at intervals of fifteen minutes.

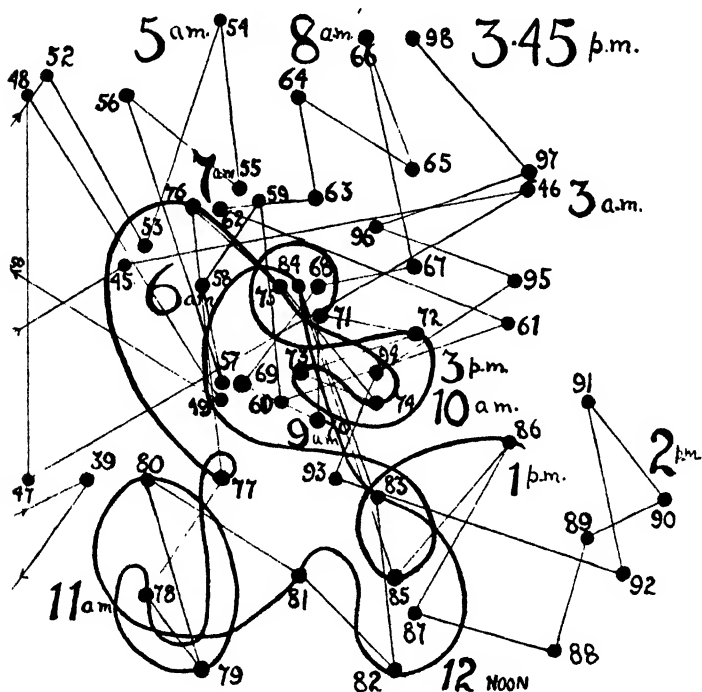
2. A record of the movement of the same shoot taken two days later from 10 a.m. to 1 p.m. at intervals of five minutes. In this case recording of the minute increments was rendered practicable by the interposition of a large bull's-eye lens between the plant tip and the horizontal glass plate; this gave sufficient magnification to allow of the successive five-minute positions being recorded as separate points.

The following are some of the results accruing :—

The influence of light and temperature as limiting factors was demonstrated. In Record I long increments from 11 p.m. to 3 a.m. (night 14th/15th) were markedly contrasted with the short increments from 3 a.m. to 3.45 p.m. (day 15th). In the latter the limiting action of light was indicated. The same influence came out in an interesting way in Record II. For half an hour at midday there was a thunderstorm, when the light intensity fell and the temperature rose several degrees. The result of the two factors acting in the same direction is manifest in the long increments. On the afternoon of the

14th there was an alternation of fitful periods of bright sunshine and dullness, and the result was seen in the varying increments of the first part of Record I.

The next interesting feature brought out is the path followed by the moving tip from point to point. This is demonstrated particularly in the graph from 9 a.m. to 1 p.m., i.e. during



the period of continuous watching and freehand graphing of the moving tip.

Instead of pursuing a more or less flat curvilinear route from point to point, the tip was swung out in a series of wide semi-circles or S-shaped tracks and these approximately alternated. (See black curve in graph.)

To analyse these movements in detail was the purpose of the second record, where it was seen that the S-shaped tracks are made up of alternating reversals of clock and counter-clock movements, taking place in some cases in uniform times.

In connection with this work I have to express my indebted-

ness for facilities and supervision accorded me in St. Andrews University Botanical Department. I have also to thank my friends, former or present students of the Department, Miss M. A. Ross, B.Sc., Miss Isabella S. M'Nicoll, and Miss Frances Erica Smith, for kindly acting as successive reliefs during the period of the twenty-four hours' recording.

THE SCOTTISH ALPINE BOTANICAL CLUB EXCURSION, 1927.
By Rev. J. J. MARSHALL LANG AIKEN, B.D.

(Read 18th October 1928.)

Choice was made of Fortingall, Perthshire, as affording ready access to Glen Lyon, a district which had lately obtained fresh botanical celebrity by the discovery of *Carex microglochin*, not hitherto reported in Britain.

The Club reached it on 2nd August through Aberfeldy, and found comfortable quarters in the modernised hotel there. Having some time at their disposal before dinner, they strolled out to take their bearings, and visited the parish churchyard close by in which a Yew (*Taxus baccata* L.) of hoary antiquity still maintained existence. "It is believed to be the oldest in Britain, and is now a mere shell, the only part remaining being the outermost portion of the old trunk, which is 56 feet in girth near the ground" (Veitch's "Manual of the Coniferae," 1900, p. 132). It is on record that, in the course of his visit to Scotland in 1770, Pennant made measurements of it, from which De Candolle made bold to estimate its term of life as not less than 2588 years! Being enclosed by a wall, its present dimensions are not easily obtained; but from a photograph taken by one of their number some idea of the vigour of one or more of its offshoots was gained.

In spite of the continuously inclement weather recently experienced throughout the island, there seemed a prospect of a change for the better, which justified the requisitioning of a car on the following day, to convey the members five miles up Glen Lyon. Next morning, accordingly, they were astir betimes, and, seated in a serviceable vehicle, entered the Glen through a deep and imposing pass, which hemmed in the waters of the Lyon in a rocky gorge beneath. The road skirted the river throughout its course; but as the ground selected for observation lay to the south, advantage had to be taken of the bridge at Invervar. On making their way down to it they were not a little surprised by a luxuriant growth of Musk (*Mimulus moschatus* Dougl.) revelling amid the herbage of a runnel by the side of the path, having dis-

carded the trig appearance assumed by it in pots and borders. Thereafter crossing the river and following a hill track above its banks, they were greeted with a display of *Gentiana campestris* L., to all seeming white, though its petals were not unfolded, which studded the meadow for a mile or more, and reached a considerable elevation as their subsequent ascent bore witness.

At the farm of Invernain a halt was called, for, though supplied with a trustworthy chart of the route to Meall Garbh, the party deemed it expedient to consult the shepherd there, who confirmed the accuracy of the information in their possession. Setting out to climb in the direction of Coire Buidheag, as indicated on the map, they left the clump of Firs on the left, and diverging westwards held up a tributary of the main hill-stream, which flowed from what was known locally as the Yellow Corrie. By so doing they gained a more gradual means of ascent; and in the course of two hours or more found themselves below its rocky ledges. The swampy ground beneath provided a typical haunt for Alpine Sedges and occupied attention for some time, as two reported associates of *Carex microglochin*, namely, *C. atrofusca* Schk. and *C. saxatilis*, L., were growing in quantity. At this point considerable ground was carefully examined with the view of gathering the Sedge in question; but in spite of their diligence, those in quest of it had to pass on unrequited.

The Corrie itself proved comparatively easy and its ledges productive, many of the plants common to the region being noted. Bird-life was scarce, and birds of prey conspicuous by their absence. Excellent pasture on the lower ground supported a heavy stock of black-faced sheep. Along the course of the stream *Lastrea montana* T. Moore grew in profusion, from the mass of which one member collected a distinct truncate form. The downward journey was uneventful though it tried the joints of all; and a pleasant run from Invervar brought the party to the hotel in time for dinner.

Among other plants sighted or gathered the following may be mentioned: *Thalictrum alpinum* L., *Cochlearia alpina* Wats., *Viola lutea* var. *amoena* Huds., *Cerastium alpinum* L., *Arenaria sedoides* Druce, *Silene acaulis* L., *Rubus saxatilis* L., *R. Chamaemorus* L., *Parnassia palustris* L., *Saxifraga stellaris* L., *S. hypnoides* L., *S. oppositifolia* L., *S. aizoides* L., *Epilo-*

bium anagallidifolium Lam., *E. alsinefolium* Vill., *Gnaphalium supinum* L., *Vaccinium uliginosum* L., *V. Vitis-Idaea* L., *Armeria maritima* Willd., *Lysimachia nemorum* L., *Polygonum viviparum* L., *Salix herbacea* L., *Listera cordata* Br., *Tofieldia palustris* Huds., *Kobresia bipartita* Dal. Tor., *Carex capillaris* L., *C. Oederi* Retz., *C. pilulifera* L., *C. pallescens* L., *C. atrofusca* Schk., *C. rigida* Good., *C. echinata* Murr., *C. pulicaris* L., *C. saxatilis* L., *Poa alpina* L., *Asplenium viride* Huds., *Athyrium alpestre* Milde, *Cystopteris fragilis* Bernh., *Polystichum Lonchitis* Roth, *Lastrea aristata* Rendle et Britten, *Phegopteris polypodioides* Fée, *Lycopodium alpinum* L., *L. clavatum* L., *L. Selago* L., *Selaginella selaginoides* Gray.

Thursday, 4th August, was regarded as an "off" day, as more than one of the party required to return home that evening. As Loch Tay was not more than five miles distant and presented attractions because of the establishment of a number of less common plants upon its shores, it was agreed to drive to Fearnan and spend a few hours there. Alighting at the pier, the party at once came upon a beautiful pink form of the Bladder Campion (*Silene Cucubalus* Wibel), Wild Basil (*Clinopodium vulgare* L.), and two stately Hawkweeds (*Hieracium gothicum* Fr. and *H. auratum* Fr.). Amid the scrub which fringed the Loch, *Thalictrum Kochii* Fr., *Circaea alpina* L., and *Galium boreale* L. were also conspicuous. They would gladly have lingered on the shore had not the sultry character of the weather forced them to seek the shade of the highway, whose ditches had been partially cleaned out but not sufficiently to frustrate the search of the botanist. In the course of a leisurely walk there were gathered a local form of Cranesbill (*Geranium sylvaticum* var. *Wanneri* Briq.) and the Marsh St. John's Wort (*Hypericum dubium* Leers), besides other plants commonly associated with the Scottish Highlands. One of the party skilled in Fern culture had the good fortune to find among the roadman's leavings a well-marked form of *Athyrium Felix-foemina* var. *polydactylum*. Among Sedges which were frequent may be named *Carex hirta* L., *C. panicea* L., *C. diversicolor* Crantz, and *C. flava* L. As there was ample time for rumination as well as for exercise, the merits of Fearnan as a place of meeting from which to make for Ben Lawers, ascend by the burn and cross the ridge to reach the Yellow Corrie, were discussed, this alternative

route having been commended by Rev. Henry H. Harvey, to whose directions the members had been greatly indebted on the previous day.

Thus ended a short and enjoyable meeting, during which the weather had proved remarkably propitious. Sunshine, however, did not lessen the sense of disappointment caused by their failure to locate the chief object of their quest.

THE REACTION OF THE MEDIUM IN RELATION TO ROOT
FORMATION IN COLEUS. By E. PHILIP SMITH, B.A.,
Ph.D., F.L.S.

(Read 18th October 1928.)

The most favourable reaction of the medium for the production of roots by seedlings or cuttings is a matter of considerable practical importance. Small (2) has stated that an acid medium favours root production in cuttings, using Acetic Acid, 1 in 10,000. Hoagland (1) presents some interesting results of the effect of the reaction of the medium on rooting of Barley seedlings. He expresses his results in terms of relative weights of roots and tops at different *pH* values of the culture fluids, and the optimum seems to be in the region of *pH* 5.2. Experiments were undertaken with cuttings of *Coleus* to determine, if possible, the optimum for this plant.

The normal procedure at the Royal Botanic Garden, Edinburgh, is to root cuttings such as *Coleus* which require a moist bottom heat of 70°–75° F. in coco-nut fibre. This is an excellent material for the purpose, since it is light and porous in texture and holds a good amount of water without becoming sodden. It is possible to squeeze a few drops of moisture from the fibre as used in the frames, and on testing the *pH* value of this it was found to be between 4.5 and 4.7 in all cases examined. The liquid was dark brown in colour, but by using the B.D.H. Capillator the brown colour gave little trouble. It is evident, therefore, that the cuttings are normally rooted in an acid medium.

The material is very strongly buffered, large additions of acid or alkali being needed in order to change the *pH* appreciably. This made it unsuitable for an experimental medium, and various substitutes were tried. Pure quartz sand, washed in running tap-water for a week, was found not to affect the *pH* of the solutions with which it was moistened, but it proved almost impossible to remove from the roots. Glass wool was persistently alkaline, and cotton wool became sodden and did not allow access of air to the roots. It therefore became obvious that water cultures were the most suitable method in this case. Preliminary trials were made with unbuffered

tap-water, adjusted to pH 4.5, 7.2, and 9.2 by the addition of traces of hydrochloric or sulphuric acids or of sodium carbonate. The results of these experiments have been recorded (3), and it is enough to say that a pH of about 7 was found the most favourable.

The need for a closer series of buffered culture solutions led, after considerable experiment, to the adoption of the phosphate mixtures described by Hoagland (1). Certain of Hoagland's mixtures (Nos. H 26, 27, 30, and 31) were used directly, and other combinations (indicated below by letters) were made up to suit the experiments on hand. These phosphate mixtures proved very satisfactory; they were sufficiently well buffered to retain their initial pH value for several days, making it unnecessary to renew the solutions every day, and the cuttings thrived in them better than in plain water. In order to avoid the toxic effects of distilled water, the dilutions were made up with tap-water. The Edinburgh tap-water is about pH 7.3, so that the solutions were slightly more alkaline than the values given in Hoagland's paper. The pH values were determined afresh for each batch of solution, but they were very constant.

The stock solutions were :

- (1) K_2HPO_4 , M/2.
- (2) KH_2PO_4 , M/2.
- (3) $NaNO_3$, M/2.
- (4) $NaCl$, M/1.
- (5) Na_2SO_4 , IOH_2O , M/4.

From these the following mixtures were made up, a litre at a time, which gave two or three changes of culture, pH 2.8, 4.6, 5.2, 5.6, 6.2, 6.46, 6.8, 7.0, 7.4, 7.8, (9.2). The composition of the mixtures is given on p. 55.

The cuttings were rooted in large carefully cleaned gas jars, with about two inches of fluid. They were thus surrounded by moist air, and no flagging (with consequent retardation) occurred. The cuttings as soon as made were floated in the tank of the greenhouse where the experiment was going on, until fully turgid. It was found that this simple precaution made for greater uniformity in the results, by securing an equal start for all the cuttings. The culture solutions were lightly tinted with an indicator, which enabled departures

from the original pH to be seen at a glance. The following indicators were used: thymol blue, phenol red, brom-phenol blue, di-ethyl red, methyl orange, brom-cresol green. A concentration ten times that used in the culture pots was not toxic to the cuttings in seven days.

Phosphate Mixtures. (cc. Stock Solutions per litre Culture.)

	1.	2.	3.	4.	5.	pH.
H26	19	—	1.7	0.8	0.8	7.8
27	11	11	1.7	0.8	0.8	6.5
30	—	25	1.7	0.8	0.8	4.6
31	—	10	1.7	0.8	0.8	2.8 (+1 cc. 10 per cent. Phosphoric Acid)
A	15	10	1.7	0.8	0.8	6.8
B	10	15	1.7	0.8	0.8	6.46
C	5	20	1.7	0.8	0.8	6.2
D	—	25	1.7	0.8	0.8	5.2
AA	25	—	1.7	0.8	0.8	7.8
AB	22.5	2.5	1.7	0.8	0.8	7.4
AC	20	5	1.7	0.8	0.8	7.0
CA	2.5	22.5	1.7	0.8	0.8	5.6

The cultures all became more acid during the experiment, due to respiratory CO₂ given off from the cuttings. This was proved to be the chief source of acidity by the ease with which a current of CO₂ free air restored the initial pH. At the beginning of an experiment there was a slight amount of acid due to the leaching out of fatty acids from the cut ends of the shoots. This is correlated with differences in callus formation between the water and the fibre cultures. In fibre the cut end gives an intense reaction with Sudan III (indicating an effective wound blocking with fatty substances), and a basal meristem forms callus to a depth of three or four cells. In water the cut end shows little or no stain with Sudan III and callus formation is inhibited, but in spite of this, rooting goes on freely.

At the end of fourteen days the cuttings were removed, the roots cut off, and roots and cuttings dried to constant weight at 100° C. The results are expressed as the weight of root (in milligrams) corresponding to one gram cutting. This is not entirely satisfactory, since it is not possible to compare

the initial and final dry weights of the cuttings, but with this reservation the results are sufficiently consistent to give at least an indication of the effect of the reaction of the medium on the production of roots. The following figures give the weight of root (in milligrams), corresponding to 1 gram of cutting at the given pH values, after fourteen days at about 70° F. The figures are the mean of five or six experiments, each batch including 15-20 cuttings (except for pH 4.6, which is only one experiment).

pH of Medium .	2.8	4.6	5.2	5.6	6.2	6.5	6.8	7.0	7.4	7.8
Weight of Root (milligrams) .	200	1390	1127	1236	1245	1461	1286	1304	1081	1186

Another criterion which might be used is the number of root primordia produced in a given time. Counting the primordia is easy in *Coleus*, because they are visible from the outside as white points as soon as they are recognisable in section, and it was done roughly in several of these experiments. The number of roots formed varied in the same general way as the total weight of roots. While this method would indicate the effect of the reaction of the medium on the production of *root meristems*, it was felt to be less satisfactory than the other because it does not take into account the aftergrowth of the roots, which is the important thing from the cultivator's point of view.

It will be seen from these data that the optimum reaction for this plant in water culture is about pH 6.5. The amount of growth falls off on either side of this point, with a slight secondary peak at pH 7.8. This is slightly more alkaline than the value found for Barley by Hoagland.

The effect of the buffer solutions on the retention of acidic and basic dyes by the stem was tested in two ways. First, stems were allowed to stand in the various buffers for twenty-four hours and then sections made of the exposed end. Secondly, sections were cut of living material and then soaked in the buffers for the same length of time. The results from the two methods corresponded. Both Hoagland's phosphate mixtures and the B.D.H. "Universal Buffer Solution" were

used. After staining for five minutes in 0.5 per cent. aqueous Eosin (acidic) or 0.5 per cent. Toluidine Blue (basic), the sections were washed in the buffer solutions and examined under the low power. The Eosin gave a clear-cut result: at pH 7.8, 7.4, 7.0, 6.8, the stain was taken up by the walls of the new wood and the fibres, but not by the protoplasm. At pH 6.5, 6.2, 5.2, the protoplasm stained strongly and retained the stain after washing. With Toluidine Blue the stain was retained strongly down to pH 7.0, and weakly below that point. The retention of the dyes was most marked in the living cells of the pith and the interfascicular cambium. The cortex did not give so good a reaction. This points to an isoelectric point for these tissues in the region of pH 6.5-6.8, and, as both these tissues are particularly active in regeneration, suggests that a reaction near the isoelectric point of the tissue favours new growth.

The condition of the reserves had a marked influence on the rooting. The cuttings were made at random from two batches of plants, one lot growing in full light and the other in a shaded house. The first had brightly coloured leaves and short red internodes, while the reserves were mostly starch, with traces of reducing sugars. The second batch had larger and paler leaves, and longer internodes with no red colour. The chief reserves were reducing sugars. The "starch" plants produced more roots and produced them more quickly than the "sugar" plants. In all cases there was a basipetal concentration of reserves in the cutting after a few days.

Testing the two types separately showed that, while the absolute amount of root produced at a given pH was greater in the case of the "starch" plant than in the case of the "sugar" plant, the relative effect of the different reactions of the cultures was similar. Therefore in most of the experiments the material was a mixture of the two lots of plants.

SUMMARY.

1. Stem cuttings of a form of *Coleus Blumei* were rooted in water cultures of various pH values, using dilute mixtures of phosphates.
2. A reaction of pH 6.5 was found to be the most favourable for root production.

3. An isoelectric range of pH 6.5–6.8 is suggested for the principal tissues of the stem.

4. The total carbohydrate of the stem influences the absolute amount of root produced, but the relative effects of the different media on root production are independent of this.

5. Root formation is not affected by the inhibition of callus formation in water culture.

REFERENCES.

- (1) HOAGLAND, D. R. (1917): Effect of H^+ and OH^- Concentration on Growth of Barley Seedlings, *Soil Science*, iii, 547.
- (2) SMALL, JAMES (1923): Rooting of Cuttings in Acidic Media, *Gardeners' Chronicle*, ser. 3, lxxiii.
- (3) SMITH, E. PHILIP (1926): Acidity of the Medium and Root Production in *Coleus*, *Nature*, cxvii, 339.

THE CAUSAL PARASITE OF THE LILY DISEASE.
By JAMES WRIGHT, B.Sc.

(Read 18th October 1928.)

In 1889 Marshall Ward (10) described in detail a disease of lilies, now usually referred to as the lily disease, and showed that the causal organism was a species of *Botrytis*. He proved beyond doubt the pathogenicity of the fungus, and showed that it conducted its parasitic existence by means of enzymes and toxins. Since the publication of that now classical paper, it has been generally assumed that the pathogen was the common saprophyte, *Botrytis cinerea*, although Ward drew attention to the fact that it exhibited a difference in size and rapidity of germination of the conidia, and also in the time elapsing from spore germination to the formation of the characteristic *Botrytis* "Haft-organen." As far as could be ascertained no more literature on this subject has been published.

Recently an outbreak of disease among lilies (*L. candidum*) occurred in a garden near Edinburgh. The symptoms of the malady and the characteristics of the parasite correspond in detail with the description given by Ward. A fungus received from Long Ashton, Bristol, isolated from diseased specimens of *L. candidum* grown in that locality, also agreed with the description.

SYMPTOMS AND COURSE OF THE DISEASE.

The external symptoms of the disease are the appearance of orange-brown specks on the leaves, stems, pedicels or buds, and thereafter the affected parts turn brown and shrivel up. The reproductive organs of the fungus appear on decaying portions and, sometime later, sclerotia, primarily white and then black, partially embedded in the tissues, are formed abundantly.

CHARACTERS OF THE PARASITE.

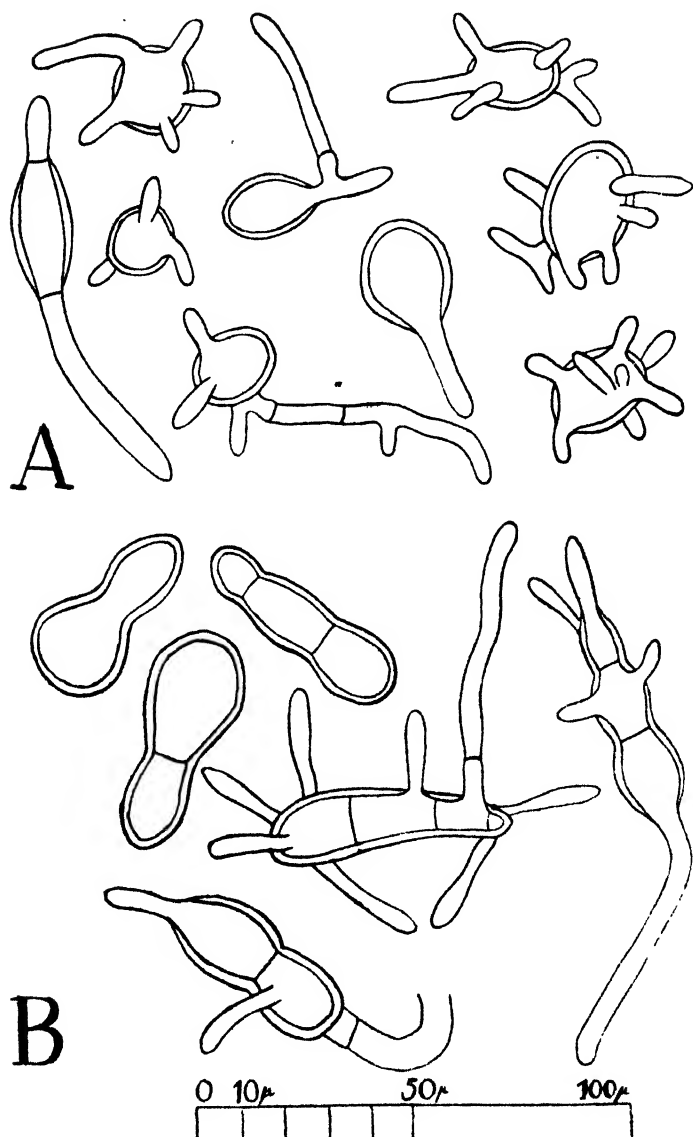
The mycelium exhibits the typical peculiarities of a *Botrytis*. It is septate, frequently branched, and varies in diameter

with the conditions under which it lives. The tips of young vigorous hyphae may be curved. Complex tassel-shaped organs of attachment are formed, but not so early, nor in such abundance as in the case of *B. cinerea*. Other important features are the fusion of hyphae, which may be observed in three-days-old cultures, and the exudation from the hyphae of droplets of a translucent nature, which were shown by Ward to contain the cellulose-dissolving ferment.

The conidiophores arise directly from the mycelium as thick, blunt, erect hyphae, full of protoplasm. They become septate and are dark brown when mature, except at the apex where they remain hyaline. They measure 12–16 μ in diameter but are more or less indeterminate in length. Under the conditions in a moist chamber, after producing a terminal head of conidia, the main axis may proliferate and produce another head, and the process may be repeated several times. On one conidiophore the successive development of ten heads of conidia has been observed. As the atmosphere dries, the conidiophore becomes flattened and twists on its axis.

The conidia are attached by short sterigmata. Primarily they are minute, globose, and colourless, but as they mature they become ovoid and the walls assume a sepia hue. The average size of mature conidia is 25–26 $\mu \times 18 \mu$, but the variation in dimensions is considerable; the range in length is 18–32 μ and in breadth 13–24 μ . On Quaker-oat media and on potato slopes, bizarre types of spores are of common occurrence. These assume a variety of shapes and may be twice as large as the normal conidia. The wall may be constricted in one or two places and corresponding cross septa appear, or one feature may occur independently of the other (fig. B).

The conidia, when placed in a drop of distilled water, tap water, or nutrient solution, usually begin to germinate at once. At first, one or two germination tubes are produced, apically or laterally, but the number is generally increased. After two days, in "hanging-drop" preparations, kept at room temperature, the number of germ tubes is found to vary from one to eight per conidium (fig. A). The number appears to be independent of the medium, but the tubes are stouter and more strongly growing in good nutrient media. A



A. Types of germination of normal conidia after two days in tap water.
 B. Bizarre forms of conidia found in cultures on Quaker-oat media and on potato slopes; three spores, of which one is still *in situ*, are shown in the process of germination. (Camera lucida.)

common phenomenon is the germination of the conidia *in situ*.

The sclerotia, first white, then black, as mentioned previously, are flattened, somewhat convex structures, which vary widely in shape and size. They are very much smaller than those of *B. cinerea* and are very similar to those of *B. tulipae*. The commonest type of naturally occurring sclerotium is circular, with a diameter of one millimetre, but elliptical and more or less irregular forms are plentiful, varying in length from 1-6 mm., in breadth from 0.5-1 mm. In culture, the size of sclerotia varies with the amount of drying to which the medium is subjected. The sclerotia, on germination, produce typical conidiophores bearing typical conidia.

Microconidia were not observed, although careful observations were made over a period of three months, and it seems probable that these are altogether absent from the life-history.

NOMENCLATURE.

Following the assumption of Ward, the first record of the disease is to be found in "The Gardeners' Chronicle" of 1881, in the form of a letter, with a reply by Berkeley (1). The fungus is reported as attacking all species of lilies, with *L. auratum* outstanding in susceptibility. Berkeley states that the fungus is presumably allied to *Peronospora*, with spores similar in shape and size to many of the large *Pezizas*, and names it, provisionally, *Ovularia elliptica*—"floccis hic illic nodosis, sporis magnis ellipticis laevibus." Saccardo (8) in 1886 gave the following description: "Hyphis abbreviatis hinc inde nodulosis, articulatis, e mycelio repente oriundis; conidiis ellipsoideis, hyalinis, majusculus. Hab.: In Liliorum varietatibus pluribus in Britannia." In 1888 Smith (9), on very insufficient evidence, changed the name to *Peronospora elliptica*. His scale drawings of the conidia and conidiophore correspond closely with the *Botrytis* described by Ward, who seems to be absolutely justified in arriving at the conclusion that all three fungi were the same.

In a recent paper by Dowson (3) reference is made to the lily disease, and it is stated that probably the same species of *Botrytis*, which is "certainly not *B. cinerea*," is parasitic on Spanish and other bulbous Irises. A *Botrytis* attacks lilies

in Bermuda, but in this case the pathogen appears to be *B. cinerea*. Fujikuro (5) in 1914 published an account of a Botrytis disease of *L. longiflorum* in Japan. It is noteworthy that the description corresponds somewhat with the case under record, but the fungus, which the author describes as a new species, *B. liliorum*, appears to be distinct. The conidia are pale grey and average $32\ \mu \times 27\ \mu$, with the range in length and breadth respectively $28\text{--}37\ \mu$ and $21\text{--}31\ \mu$, and they germinate with the production of only 1-2 hyphae.

It is interesting to note that the fungus under investigation, as regards length of conidia and number of germ tubes, is intermediate in character between *B. cinerea* and *B. polyblastis*, a new species recently described by Dowson (4).

	<i>B. cinerea</i> .	The Lily-fungus.	<i>B. polyblastis</i> .
Average spore length	10 μ	25-26 μ	40 μ
No. of germ tubes	1-3	1-8	8-13

Summing up, the lily-fungus, which possesses the diagnostic characters of the genus *Botrytis*, has the following specific features :—

1. The conidia are large, averaging $25\text{--}26\ \mu \times 18\ \mu$.
2. One to eight germ tubes are produced.
3. As compared with *B. cinerea*, it fruits poorly on synthetic media.
4. In culture, the organs of attachment are not formed so early nor in such abundance as in *B. cinerea*.
5. The sclerotia are similar to those of *B. tulipae* and quite distinct from those of *B. cinerea*.
6. There is a probable absence of microconidia.

It is deemed that the above points are indicative of a distinct species, and adopting the specific term of Berkeley and Smith, the name *Botrytis elliptica* is suggested.

***Botrytis elliptica* (Berk.) Wright.**

Ovularia elliptica Berk.

Peronospora elliptica (Berk.) Smith.

Mycelium septate, branched, variable in diameter, with cross connections, organs of attachment, and exudation of droplets of ferment. Conidiophores arising directly from the mycelium, $12\text{--}16\ \mu$ broad, indeterminate in length, septate, proliferating, brown when mature except at the apex, where

they remain hyaline, flattened when dry and twisted on axis. Conidia in groups on conidiophores or short branches of the ordinary mycelium, attached by short sterigmata, ovoid, hyaline with sepia wall, $18-32\ \mu \times 13-24\ \mu$, averaging $25-26\ \mu \times 18\ \mu$, germinating by the production of 1-8 germ tubes; bizarre forms common on artificial media. Sclerotia first white, then black, flattened, convex, circular, 1 mm. in diameter, elliptical, irregular, $1-6\ \text{mm.} \times 0.5-1\ \text{mm.}$ Microconidia absent.

CONTROL MEASURES.

1. *Position*.—The disease, usually sporadic, may become epidemic if the plants receive a sudden and severe check during the growing season, as is caused by a period of cold, stormy, wet weather. As the prevailing winds at such a time are N. or N.E., the lily bed, if possible, should have a sheltered, southern exposure.

2. *Sanitation*.—All plants when they show signs of attack should be removed and burned. The disease, if allowed to run its course, will be spread by the conidia, and carried over to another year by the sclerotia which find their way into the soil.

3. *Spraying*.—Ogilvie (7) reports that in Bermuda the Botrytis blight of *L. longiflorum* var. *Harrisii* is adequately kept in check by spraying with Bordeaux mixture. Hopkins (6), however, states that in experiments at Wisconsin on the spraying of tulips for *Botrytis*, a 5-5-50 mixture caused considerable injury to the leaves and flowers, besides giving them an unsightly appearance. According to Bewley (2), the specific spray for *Botrytis* is a 2 per cent. solution of Calcium Bisulphite, which is used to destroy fungal infection on the soil surface.

SUMMARY.

An outbreak of a Botrytis blight of lilies is recorded. The disease and the causal parasite agree with the description given by Marshall Ward. The fungus is distinct from the species causing disease of lilies in Bermuda, and also from the species parasitic on lilies in Japan, and is described as a new species *Botrytis elliptica*. A note is added on control measures which may be adopted.

The writer acknowledges his indebtedness to Mrs. N. L. Alcock for material and valuable assistance, and to Dr. Malcolm Wilson, Mycology Department, University of Edinburgh, where the investigation was carried out; also to L. Ogilvie, Esq., M.A., B.Sc., Advisory Mycologist, Long Ashton, late Plant Pathologist, Bermuda, for his kindness in sending fungus cultures.

REFERENCES.

- (1) BERKELEY, Rev. M. J. : Gard. Chron., N.S., xvi (1881), 340.
- (2) BEWLEY, W. F. : Diseases of Hothouse Plants (1923), p. 65.
- (3) DOWSON, W. J. : Some Fungus Diseases of Bulbs. Journ. Roy. Hort. Soc., lii (1928), 49.
- (4) — On an Extraordinary Botrytis, causing Disease of Narcissus Leaves. Brit. Myc. Soc. Trans., xiii (1928), 95 *et seq.*
- (5) FUJIKURO, Y. : On a New Fungus Disease of Lilies caused by *Botrytis liliorum*, Fujikuro, n.sp. Bot. Mag. Tokyo, xxvii (1914), (228) (Japanese).
- (6) HOPKINS, E. F. : The Botrytis Blight of Tulips. Cornell Univ. Agr. Exp. St., Mem. 45 (1921).
- (7) OGILVIE, L. : Rept. Plant Pathologist in Rept. Dept. Agr. Bermuda for 1925 (1926), ex. Rev. Appl. Myc., vi (1927), 16.
- (8) SACCARDO, P. S. : Sylloge Fungorum, iv (1886), 145.
- (9) SMITH, W. G. : Disease of Lilies. Gard. Chron., 3rd ser., iv (1888), 184.
- (10) WARD, MARSHALL : A Lily Disease. Ann. of Bot., ii (1889), 184 *et seq.*

TRANSACTIONS
OF THE
BOTANICAL SOCIETY OF EDINBURGH

SESSION XCIII

VEGETATIVE PROPAGATION. LEAF CUTTINGS IN GYMNO-
SPERMS. By R. J. D. GRAHAM and L. B. STEWART.
(With Pl. III.)

(Read 18th October 1928.)

The possibility of vegetative propagation in the Gymnosperms is not so limited as it is generally supposed to be. Stem cuttings is the favourite method employed in their propagation. In selecting wood from plants with horizontal branches for cuttings the necessity for the selection of orthotropic shoots has long been known. It may here be pointed out that the forms of *Picea*, *Larix*, *Cedrus*, etc., distinguished in horticulture by the terms *nana*, *pendula*, *pygmaea*, etc., are invariably rooted side branches of the orthotropic species. Resin exudation has been reported as a hindrance to callus formation and rooting in stem cuttings (1).

The use of root cuttings is not widely known, but the second author has been successful with *Araucaria Cunninghamii*, *Ginkgo biloba*, *Podocarpus macrophylla* and *Hallii*, and *Pinus sylvestris*.

In 1928 for the Glasgow Meeting of the British Association for the Advancement of Science an endeavour was made to extend the vegetative propagation of Gymnosperms by the use of leaf cuttings. Success attended the attempt in the

cases of *Ginkgo biloba* and *Podocarpus macrophylla*. No special treatment other than that given to ordinary cuttings at Edinburgh was employed (2). In *Ginkgo* roots developed in a most satisfactory manner in a few weeks and a shoot appeared in due course. A period of months elapsed before the *Podocarpus* leaves rooted. In each case the percentage of leaves rooting was high. Plate III illustrates rooted specimens of the plants referred to.

In the case of *Ginkgo*, callus develops on the injured end of the petiole which covers the whole cut surface, and may develop into a considerable mass. Anatomical examination of the leaf base reveals the normal sequence of events. All the living cells take part in callus formation, but the cells surrounding the paired vascular trace initiate the development. The first root initial appears on the adaxial side of the petiole, and originates in the area of small parenchyma cells lying in the bay formed by the two bundles. The passage of the root through the incumbent tissues is marked by elongation of the surrounding cells. Further roots are initiated in the callus covering the leaf base and obtain vascular connection through the short tracheids in the central portion of the callus. The subsequent growth of the roots is strong, and the roots themselves are unusually stout for those produced by a leaf cutting. The shoot initial is first seen as a swelling at the union of the first root and the leaf base, and makes its appearance on the adaxial side.

Podocarpus leaves gave slower results and developed roots only after an interval of several months. The injured leaf base is covered by a heavy callus. Unlike the callus in *Ginkgo* the outer layers are brown, a feature often associated with slow after-development. The centre of the callus consists of exceedingly numerous short tracheids with simple slit-like pits. Roots ultimately develop on the adaxial side of the callus. These roots unite with the single vascular bundle of the leaf either through the complex tracheidal mass or laterally at the corner of the crescentic leaf trace. At the time of writing shoot initials have not appeared, but this is only a matter of time now that the leaves have an established root system. In this respect the authors' experience has been more successful with leaf cuttings than Kupfer's (3). Species of *Acanthus*, *Acalypha*, *Alloplectus*, *Alsomitra*, *Brownea*, *Chirita*, *Coleus*,



Rooted leaves of *Ginkgo biloba* and *Podocarpus macrophylla*.

Dioscorea, *Eranthemum*, *Ficus*, *Gasteria*, *Gesneria*, *Jacobinia*, *Kopsia*, *Medinella*, *Panax*, *Peperomia*, *Rosa*, *Ruellia*, *Sanchezia*, *Sansevieria*, *Vitis*, *Zamioculcas*, to quote some examples, have all been raised by leaf cuttings.

The authors desire to express their thanks to Mr. W. Murray and Mr. A. H. Whyte who carried through the practical cultivation of the leaves with exemplary care and praiseworthy pertinacity. To Mr. R. M. Adam we are indebted for the photograph of the *Ginkgo* leaves.

REFERENCES.

- (1) BALFOUR, I. BAYLEY : *Gardeners' Chronicle*, lii (1912), p. 384, and *Journ. R.H.S.*, xxxviii (1913), 447.
- (2) STEWART, L. B. : *Journ. R.H.S.*; lii (1927), 33.
- (3) KUPFER, E. : *Mem. Torr. Bot. Club.* xii (1907), 195.

VEGETATIVE PROPAGATION. *KALANCHOE VERTICILLATA*.

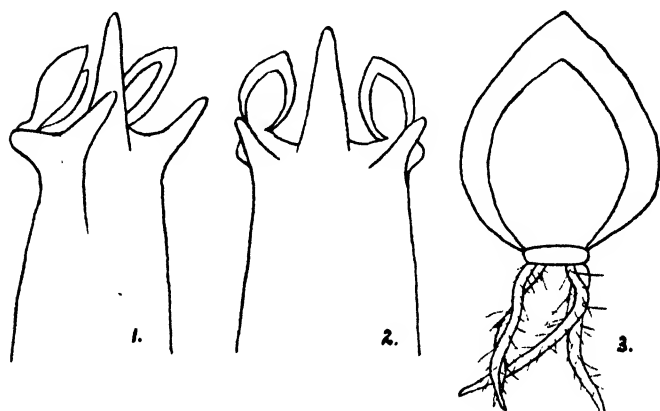
By C. M. BARON, R. J. D. GRAHAM and L. B. STEWART.

(Read 18th October 1928.)

The leaves of *Kalanchoe verticillata* are described by Elliot (1) as ending in five small teeth, three linear erect and two broad reflexed with a gland in the centre. The plants in cultivation at the Royal Botanic Garden, Edinburgh, received in 1928 and 1929 from T. Sharp, Westbury, Wiltshire, exhibit certain features of interest. The leaf ends in a small linear tooth, while on the leaf margin towards the apex occur in pairs a varying number of lateral teeth each with a linear point and a reflexed claw. The development of the claw is greatest on the highest pair of teeth. The claw is an outgrowth from the base of the lateral linear tooth showing first as a small projection on the free (exterior) side of the tooth. Subsequent growth renders the claw the more prominent feature as a projection from the tooth towards the dorsal side of the leaf. Their development is centripetal, the size decreasing as the leaf is descended. At an early stage in the development of the claw the apex appears to terminate in a small green incurved tip. At a later stage this is clearly recognisable as a bud consisting of a white disc-like base bearing two leaves. The plane of the leaves is parallel to that of the main leaf; they are very unequal in size, the larger being towards the free (dorsal) side of the main leaf. The bud, though at first apparently terminal, ultimately is slightly removed from the apex of the claw. This change in position is due to the growth of the claw. Roots develop from the disc at the base of the buds on detached leaves, the first root being directly below the smaller leaf. In old leaves the buds fall off, while in younger leaves on drying the buds become detached leaving a circular scar—the gland mentioned in the description.

The leaf outline in transverse section below the highest pair of lateral teeth is reniform with a depression on the ventral surface. Six bundles traverse this portion of the leaf—a double median pair and on each side a pair of laterals. On approaching the region of the teeth the median bundles join and continue

as a single trace into the terminal tooth. The lateral bundles on each side approach each other and run parallel at the base of the lateral teeth. The external member of each lateral pair is continued into the linear tooth, while the internal member bends sharply and passes into the reflexed claw, terminating at the bud. The bud originates from a conical group of



Kalanchoe verticillata. Leaf apex. 1. Side view showing one pair of buds. ($\times 9$) 2. Front view (upper side of leaf) showing same. ($\times 9$) 3. Vegetative bud rooted on ordinary soil, about five to seven days old. ($\times 15$)

meristematic cells extending from close to the vascular trace to the epidermis. Leaf primordia are laid down on this cone, the first on the free side of the cone. A flattened circular area of meristematic cells is intercalated between the cone and its attachment to the claw. From this disc the roots arise as previously described.

The production of these buds offers an interesting addition to the types quoted by Holm (2). They are a constant feature of the plant as in *Malaxis* and *Bryophyllum*. Unlike the latter they appear at an early stage of the leaf development, while in contrast to the former they drop off when mature.

The thanks of the authors are rendered to Miss E. Stott for microtome sections of the early stages in development.

REFERENCES.

- (1) ELLIOT, G. F. S.: Journ. Linn. Soc., xxix (1891), 14.
- (2) HOLM, T.: Ann. Bot., xxxix (1925), 867.

PHYSICAL CHANGES BROUGHT ABOUT BY THE FLOATING
POWER OF SEAWEED. By SYMINGTON GRIEVE. (With
Pl. IV.)

(Communication No. 1, read 10th March 1881.)

*Note on the Physical Effects produced by the Floating Power of
some of the family Fucaceæ as observed at the Strand between
Colonsay and Oronsay, August 25, 1880. (Reprinted
from Trans. Bot. Soc. Edin., xiv, pt. 2 (1882), p. lviii.)*

Towards the end of last August we were on a visit to the island of Colonsay, and on the 25th of that month we determined to make an excursion to the island of Oronsay, which is divided from Colonsay by a beautiful sandy strand that varies in breadth from half a mile to a mile and a quarter. At ordinary full tides there is a depth of water upon the strand of from six to nine feet, and there is a period of from three to six hours each tide during which the strand is dry.

The sand is mixed with immense quantities of comminuted shells, which gives it a white appearance; and the inner part of almost every bay that indents the coast has similar tracts, while the promontories are rugged, and their shores strewn with stones, some of which are water-worn, while others bear evidence of having been recently detached from the neighbouring rocks, and on these stones there is a luxuriant growth of seaweed.

To arrange for an excursion to Oronsay it was therefore necessary to know at what hour the tide would recede from the strand, so that the visitor might get across as soon thereafter as possible, and take the full advantage of the time that would elapse before the tide made it necessary to recross again. On the occasion of our excursion we arrived a short time before the falling tide had left it, and instead of waiting we determined to wade through, so as to get more time on Oronsay. We took to the water, which was from twelve to eighteen inches in depth, and had not gone far when we found that there were very strong currents running westwards and eastwards towards the open Atlantic, and here and there upon the sandy bottom we saw sinuous markings that might have been the grooved,

tortuous tracks of immense eels as they made their way seawards ; and we went on in the hope that as we got farther from the shore we would come across one of these fish.

But though the courses were numerous still we saw nothing that to our mind could make them, until suddenly, about mid-channel, we observed that one of these markings seemed either to begin or end at the foot of a large stone ; but though we lifted the masses of seaweed that were attached to it, in the hope that below we should find a veritable sea-serpent, still we were disappointed. A little farther on we came to another which again terminated at a stone, and as we looked on, considering what could be the solution of the problem, the stone moved ; we thought we must be mistaken, so we watched it carefully, and after a pause it began to travel westwards, and having got over a ridge of sand into deeper water it proceeded much faster ; and as it journeyed, buoyed by the seaweed, and dragged by the current, it left a trail behind. At last the mystery is solved, the buoyant power of the air-vessels of the seaweed is half lifting the stone from the ground, and as the current carries the weed along it waves from side to side, conveying the same motion to the stone, which leaves a winding impression on the sand. A further examination of the courses showed us that all were not alike, some being quite straight, and we noticed several where the stone, after travelling a straight course, had been left dry upon the sand, and when the tide flowed again had been driven off at an angle back upon its first track, leaving a trail much like the letter V. Some courses intersected each other, and occasionally sinuous and straight courses were to be thus found in combination.

Now, may this not cause reflection as to what may be the real solution of some supposed reptilian marks upon sandy or muddy beaches, whether ancient or modern, especially if they occur where there is a great fluctuation in the rise and fall of the tides, and at the same time a strong current ?

It will be evident that with a receding flood tide it is quite possible, nay, even probable, that such markings would be made on stretches of mud or sand along a shore, and if the next tide did not obliterate the trails formed by the seaweed-carried stones on the upper part of the beach, most probably these markings, exposed for a time to the sun, would harden, and this operation would go on from tide to tide, until a

considerable part of the shore would be covered with the markings, and, when another series of flood tides came, the now firm moulds would be filled up with layers of fresh sand or mud, and might thus remain for ages, until some enthusiastic geologist broke up the matrices and found a new wonder.

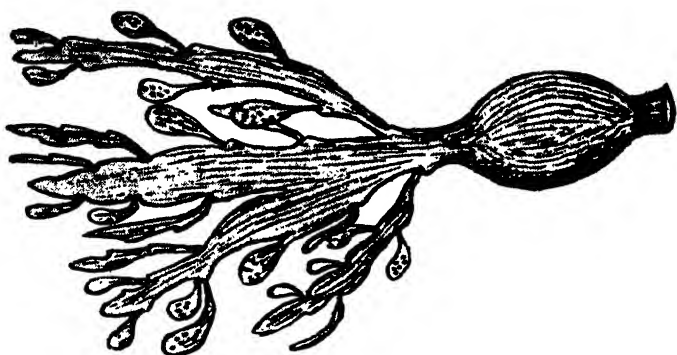
Subsequent investigations have shown us that the tracks are not soon obliterated upon the sand, and during calm weather will remain for several days quite distinct, though their sharp outlines become less clearly defined after each tide. It is also well to remark that the difference of the height to which spring and neap tides rise here is very considerable.

But to return to the strand of Oronsay; let us say, that having now got the clue to the cause of the markings, we found that there was an immense number of stones thus travelling westwards and eastwards, and that they varied much in weight, those we saw moving being from a few ounces to half a hundredweight, but we observed at various parts isolated boulders that we judged would each weigh several hundredweights, and these we think must have been carried there by seaweed.

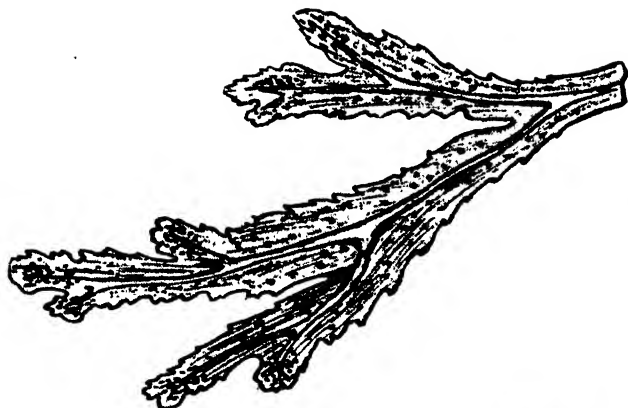
The quantity of rock thus carried out to sea by each tide is very great, and, we believe, must weigh many tons; and if this movement is in constant operation even for a few weeks or months of each year, it must be a most important factor to be kept in mind in considering the physical changes that are in operation in this part of Scotland. And if this is likely to be the case, when we consider such a narrow channel as that between Colonsay and Oronsay, what must it be if a similar force is working all along the west of Scotland? and if you extend the field for consideration, how much greater the effects?

The seaweeds attached to the stones were principally of the tribe Fucidae, and those we noticed most were *Fucus nodosus*, *serratus*, and *vesiculosus* (see figure); each of these varieties of seaweeds has, with regard to high-water mark, its own zone along sea coasts, but conjointly they cover, wherever they occur, the whole beach from high- to low-water mark, and may be arranged as follows:—

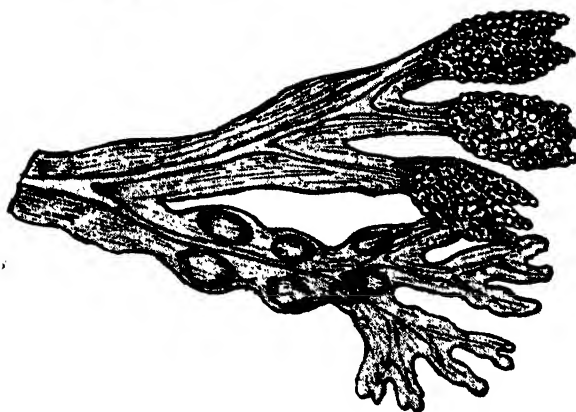
1. *Fucus nodosus*—high-water to half-tide.
2. *Fucus serratus*—about half-tide.
3. *Fucus vesiculosus*—extending from near high tide to low-water mark.



F. nodosus.



F. serratus.



Fucus vesiculosus.

But as *Fucus serratus* is devoid, or nearly devoid, of air-vessels, it may be left out of account for our present purpose.

It will be seen that with *Fucus nodosus* and *vesiculosus* we have a growth of seaweed extending from high- to low-water mark, and that for part of that distance these two weeds intermingle; and it is quite possible to find both varieties growing upon the same stones.

You will also bear in mind that both of these seaweeds are supplied with air-vessels which float the weed with the rising tide; and so great is the buoyant power that loose stones to which the Fuci are attached are raised from their beds and floated, the current transporting them in whatever direction it may set.

The result of the continued action of this carrying force will be to denude our coasts of much of the detached and broken rock around them; and if these fragments are carried out to sea, floated by these vegetable buoys, they will ultimately be deposited at the bottom of the ocean, for periodically the seaweed will decay off, and then the stones freed from their floats will sink.

These individual stones as units may seem insignificant factors in the physical changes continually going on, but in the aggregate they represent a mighty force filling up the ocean bed. But this is not all; for we have evidence that another and perhaps more important operation is going on as regards the position of sea and land.

Our observations led us to notice that at a place where a stone was left by the receding tide it sank, and that all except flat stones went downwards until they were checked by the resistance offered by the sand to the great surface of the attached masses of seaweed. Most of the stones which thus rest in transit across the strand rise with the succeeding tide, but at certain seasons, we believe, many sink in the sand to rise no more, owing to the attached seaweed either rotting off or losing its buoyant powers, and stones thus deposited are slowly but surely forming a barrier, which will in time become an isthmus between Colonsay and Oronsay; then we shall find the latter island as a peninsula to the former, and as the sand accumulates on each side of the isthmus, it will gradually increase in breadth, until instead of being a peninsula Oronsay shall really form a southern point to Colonsay.¹

¹ At times a portion of the sand upon the strand changes its position, and the deposited stones can then be seen.



Having been led to this conclusion, we made inquiries among the natives as to their actual observation, and while some inclined to think the depth of water on the strand at high tide was not quite so great as it used to be thirty or forty years ago, still all were not entirely agreed, the fact being that no one had made accurate observations. However, we succeeded in obtaining evidence which quite corroborates our view as to the change referred to being in operation in the immediate neighbourhood.

Near the western entrance to the sound that divides Colonsay from Oronsay, and on which is situated the strand, there is what is now the south-west point of Colonsay, and this promontory is known by the name of Ardskinish,¹ but this name properly refers to the extreme point, its etymology being, *Ard*, high, and *innis*, island, and this exactly describes what this place was until about seventy years ago, the outer point being an island at high water, and the low-lying tract between it and the mainland of Colonsay a strand.

An old man, resident at Kilchattan on Colonsay, told us that until recently several men were living who could remember the point as an island; and he mentioned two, who are still alive, who he believed would recollect it, and he could remember himself when the neck of sand, dry at high-water, was not above 20 feet in breadth, and now at the narrowest point at high tide it will be the third of a mile; and from the accumulation of sand blown from the beach the land at some points, according to the Ordnance Survey map, is nearly 40 feet above the sea-level.

We have thus a case where the operation of filling up a strand by natural laws has taken place during the memory of men now living.

We are not aware that other observers have noticed these facts before; but it would be interesting if they have done so, to put them on record, as the subject seems worthy of fuller investigation.

¹ Ardskinish. There is a difference of opinion as to the etymology of this name. Some think it has an entirely Norse origin, but the first syllable of the word (*Ard*) is undoubtedly Celtic. The last part of the word is not so certain as to its meaning and origin.

**PHYSICAL CHANGES BROUGHT ABOUT BY THE FLOATING
POWER OF SEAWEED. By SYMINGTON GRIEVE. (With
Pls. V-IX.)**

(Communication No. 2, read 13th December 1928.)

I wish to interest you in a subject that I have had under consideration for a long time. It is one of a number of important factors that have caused physical changes in the world. The floating power of seaweed seems to have attracted very little attention, if any, from scientists. Why it has escaped notice is difficult to explain as it can be seen operating along almost every coast of the world. It may be that it forms a less important factor than some others in effecting physical changes upon the earth. To my mind, it forms an important link in the scheme by which the Great Ruler of the Universe is working out his plan. Part of the work is carried out by volcanic action, also by ice, snow, rain and rivers. The smoothed and rounded stones that we find everywhere have been mostly formed by one or other of these agencies, but others require consideration. The agitation and operations that go on in volcanic craters may round angular stones (Plate V), so may the glacial action of ice, as seen in any old moraine. In the beds of our burns and rivers we have water-worn stones. These factors may convey rounded stones to a sea coast where they would accumulate and lie, unless some disturbing agency was operating. I think you will find this to be the floating power of seaweed, about which I am going to tell you.

The great gulf that is known as the Caribbean Sea is a vast crater. There has been a great submergence, and all that is left of a great land surface is the fringe of islands that border the depression on the north and west. These islands are merely the tops of high mountains forming one of the anticlines of the world. The depths of the sea along their coasts is very great, varying from 10,000 to 18,000 feet. Above and below sea-level upon the slopes of these mountains are at places found rounded stones in quantities. Such deposits are probably due to volcanic action (Plate VI).

The Sargasso Sea to the north and west of the Antilles has, in the past, been a sea of mystery. As your ship steams over it you see vast masses of seaweed floating upon its surface, quite beautiful to look at with its yellow foliage. What naturalist who has visited that sea has not tried, with various appliances, to hook some of it as it floated by? Many an hour may have been spent trying to obtain specimens, and how often the naturalist has had to confess failure—most who have tried know. It requires special apparatus to effect capture, and that is generally to be found in possession of the cabin boy of the ship, who earns his reward.

Who has not heard of floating islands of seaweed in the Sargasso Sea, of embedded ships, of all kinds, fixed as if in the grip of an octopus, of human tragedy and loss of life? Even dynamite has been brought into requisition to effect relief to helpless crews, according to the writers of romance. I have never come across anyone who could corroborate any of these tales from actual experience, or who had thoroughly explored the Sargasso Sea.

I understand recent research by United States warships has failed to substantiate the stories of floating islands of seaweed, and although I have voyaged over parts of the Sargasso Sea more than once, I am afraid I must be classed as a doubter.

There is, however, one thing about which there can be no doubt, and that is the abundance of floating seaweed. It is mostly composed of *Sargassum vulgare* and *Sargassum bacciferum*.

The specimens of these seaweeds found floating at sea have invariably burst vesicles, but still are, more or less, buoyant.

It was long unknown where these plants grew, but within comparatively recent years they have been discovered growing upon the shores of the French islands of Martinique and Guadeloupe, and I found it also growing upon the shores of the British Island of Dominica (B.W.I.). The weed appears periodically to lose its attachment to the stones and is carried by the strong current out to sea. I have obtained one specimen at sea with a stone attached to its roots. While that is evidence of what is happening, we require much more material before forming conclusions. These seaweeds also occur in some parts of the Pacific and Indian Oceans.

The trivial name, *bacciferum*, is applied to one of the

species owing to the appearance of its air-vessels being similar to berries.

When dried as herbarium specimens these weeds lose their bright colour and are much less attractive to the eye than when seen floating upon the sea.

During the winter of 1879-80, after I had been studying the structure of the caves at Killoran Bay, Colonsay, I read a paper to the Edinburgh Field Naturalists Club upon "The Cliffs and Caves of Colonsay." I had formed the opinion that the caves had been excavated by the pounding and working of stones, by the action of the ocean waves, along the line of a vein of rock, not so hard as the rest of the cliff, that was at a right angle to the coastline. It was quite easy to form conclusions and theorise, but it was difficult to think that, without some other factor operating, inert stones could become such efficient tools as to excavate deep caves into the bowels of the cliffs. The puzzle was to find out what the unknown factor could be. It was while considering these things that I made a discovery which I have mentioned in my last paper (p. 73).

I was on a visit to the Island of Colonsay in August 1880, and on the 25th of that month, when wading across the strand that connects that island with Oronsay, I observed great numbers of stones with seaweed growing upon them moving with the strong tidal current. These stones were moved from side to side by the waving seaweed and had an oscillating motion conveyed to them. Where they touched the shore they were dragged or trundled along, leaving tracks of more than one variety upon the muddy sand. The sand is mixed with comminuted shells, but rests upon a solid ridge of stones connecting the two islands. This ridge is said to have quicksands upon each side of it, and, as I shall show presently, probably owes its existence to the stones forming it having been conveyed there by seaweed. The study of these seaweed-borne stones shows that they vary in shape and general character at different parts of our coasts. At those portions of the coast, where there are rugged cliffs or shores formed by a talus of recently fallen rock, the stones are more or less angular. This more or less angularity and the general shape of each stone has much to do with its liability, when seaweed grows upon it, to contribute to its conveyance by tidal currents from one part of our coast to another and also out to sea. In

the course of this conveyance, if they touch the ground, such stones may make markings on a sandy strand indicating their course of transit.

For instance, a flat stone exposes a much larger surface for seaweed to grow upon than a stone long and narrow, or heavier at one end than the other. Much depends upon what part of the stone the seaweed grows upon. The more luxuriant the growth and the more numerous the vesicles the more is the buoyant power of the seaweed. Naturally the portion of the stone upon which the seaweed has grown is buoyed up, while the side or end that is bare of weed and not buoyed up takes the lower place. When sharp pointed, a stone generally penetrates the sand and sometimes is engulfed. If it continues lying upon the surface or is only partially buried under sand or gravel, the exposed part of the stone is that upon which the seaweed grows: upon the unexposed part of the stone there is either no growth or very little. The seaweed periodically looses its attachment to a stone, which then sinks to the bottom and becomes inert. If above ground it remains resting until such time as seaweed once more grows upon its surface, and in sufficient quantity to render the stone buoyant. For seaweed to grow upon a stone its surface must generally be exposed. Stones covered up in sand or gravel do not as a rule have a growth of seaweed, unless the covering up is only of a temporary nature. Thus stones that sink beneath the surface of the sand, remain there unless the scour of the tide once more exposes them. Then they may cultivate a new growth of buoyant seaweed to float them to a new location.

Another factor that operates is the direction of the sea currents which cause floated stones to change their line of travel with each tide. Tides vary in strength and in the length of time they run from day to day. Thus stones may be carried much farther one day than another. Where the water is not too deep they may trail along the bottom, leaving tracks, or they may be driven out to sea, or tossed up upon a hard beach and remain there. If the resting-place of a stone be a sandy or muddy shore it may sink into or beneath the surface, so that the buoyant power of the seaweed is not sufficient to raise it out of its bed so as to float again. Much depends upon the resting-place of the stone, and also upon the shape of the stone and the incline of the beach. Stones when they sink

may form barriers or ridges on a strand, and when sufficiently large in numbers may form a connection between two islands, as is the case between Colonsay and Oronsay, or may connect an island with the mainland. The name Oronsay occurs at more than one place on the west of Scotland, and the Norsemen always gave the name to the pendicle to a larger territory. The Celtic and more ancient names for Oronsay were Toraic and Toraighe.

Sea-beaches vary very much in character. For instance, the shores of a coral atoll in tropical seas, far removed from rocky shores, may be comparatively free from stones or stones may be non-existent or very rare. This is generally owing to the isolated and insular position of coral atolls, often in mid-ocean, especially in the Pacific (see also p. 97).

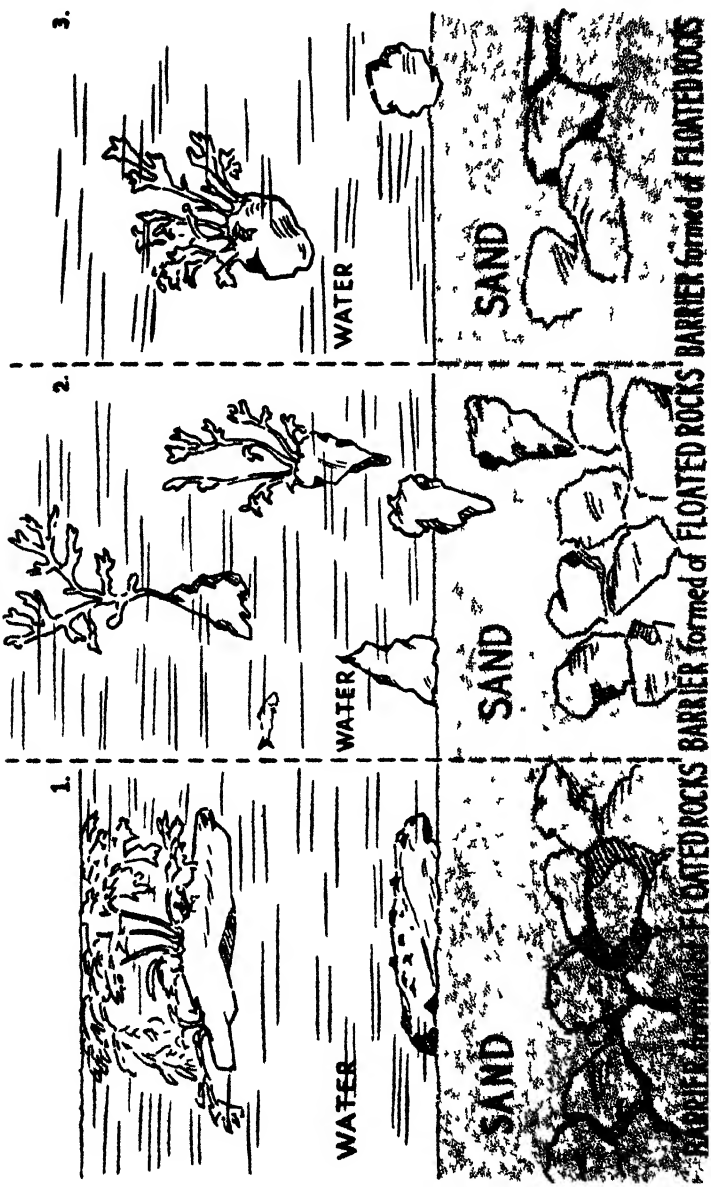
In this country we have not far to go to see sandy shores and rocky shores, near each other and sometimes alternating. Often the upper part of a beach is formed by stones, some rounded, some water-worn, and some angular, while the fore-shore is composed of sand or mud. On the upper part of some shores the stones are lying in bare heaps and are piled up in long beds. The reason that they are bare is that at high tide the waves break over them, the water rushing

[The diagram on p. 83 is to illustrate how physical changes are effected by seaweed, also the importance of the shape of stones carried by seaweed in forming barrier ridges.

Section No. 1.—*Upper part* shows a flat stone with seaweed attached. *The middle portion* of the section shows the same stone resting upon the surface of the sand after the seaweed has come off, but leaving its growth markings upon the stone. *The lower portion* of the picture shows the bed of sand, and beneath that the angular stones that have passed downwards through the sand and now form a bed upon which the ridge of strand between Colonsay and Oronsay has been formed.

Section No. 2.—This diagram shows what may happen if seaweed grows upon a stone more or less triangular in shape. Upon the left of the picture is shown seaweed attached to the sharp point of the triangular stone which is being floated by the seaweed. Below is the same stone, without the seaweed, resting upon the base of its triangle on the surface of the sand into which its broad base prevents it from sinking. On the right of the picture is shown what may happen if the seaweed should grow upon the wide base of the triangular stone. It will be floated point downwards until the seaweed becomes detached from the stone, which will then descend to the sand, which will be penetrated by the sharp point until the stone rests upon the barrier or ridge underneath the sand and forms part of it.

Section No. 3.—This diagram depicts a round stone with a growth of seaweed which floats it. On the right of the picture is the same stone sunk beneath the water, resting upon the sand where it is likely to remain until once more covered with a growth of seaweed with vesicles. The lower part of the picture shows the bed of sand, beneath which is shown the bed of stones.]



downwards among the loose stones, washing out all sand and gravel to a lower level, forming the foreshore.

Another important factor to be remembered is that it is those seaweeds with vesicles, such as members of the family of Fuci, that have most floating power. Also that their buoyant power varies according to the state of the vesicles, the weight of foreign matter adhering to the fronds, such as the calcareous coverings of *Serpula* and the shells of molluscs and other creatures.

As most seaweeds float upon the surface of the water when detached from anchorage of any kind, we may take it that such seaweeds, even without vesicles, have a certain amount of floating power. Such power is, however, very inefficient in its action when compared with the same seaweed when supplied with numerous vesicles.

As far as the British Isles are concerned, the seaweeds that are most active in their floating agency are *Fucus vesiculosus* and *Fucus nodosus*, and to a lesser extent *Fucus serratus* and Sea Whipcord, *Chorda Filum* (Plate VII).

Laminaria is active in effecting physical changes in another way. It may not have as much floating power as some other seaweeds, but its roots envelop stones, shells, and in fact everything that comes within their reach. When storms arise, especially when the tide is low, the broad fronds are washed violently by the waves, and the *Laminaria* roots are wrenched from the sea bottom and act like a patent dredge in lifting in their grip all that they have grasped, which is tossed up along with the fronds of the *Laminaria* upon the beach (Plate VIII).

Throughout the world the places where seaweeds reach their most luxuriant growth appear to be the rocky shores of the great oceans, such as the North and South Atlantic and the Pacific. We therefore find the western shores of Britain and Scandinavia suitable places to study such phenomena. The growth of the weed is encouraged by the high temperature caused by the influence of the Gulf Stream. The weed here is generally of large size, and at certain seasons is supplied with great numbers of bladders that act as floats to whatever substance the seaweed may grow upon.

A luxuriant growth of seaweed does not always continue upon a particular stone or rock. It thus follows that a stone which was at one time upon the move becomes stationary

until another crop of seaweed with vesicles grows upon it, sufficient to render it once more a buoyant object.

Evidence of what takes place is seen when a marked surface of rock is noticed to be at one time bare, showing traces of seaweed having been attached to it, and at another covered with a dense growth of the weed. It is said that the Carr Rock in the Firth of Forth has been known to be bare of Fuci in November, and next May to be clad with a dense growth, some of it six feet long.

Little seems to have been recorded about the periodicity of the growth of seaweed. The period of growth may be short, say two or three years, and then the weed begins to lose its attachment, but probably this shedding process takes place at much longer intervals. I have my reasons for thinking so and I will state one.

About the year A.D. 560 Gabrain, King of the Scots of Dalriada, whose capital was at Dun Add near Lochgilphead, Argyllshire, was defeated by Bruid, King of the Picts, who appears to have captured Dun Add. In the fighting Gabrain is said to have been killed. In any case, we find about the year A.D. 563 his son Conal upon the throne of Dalriada. He was no longer ruling from Dun Add but had retired south to Dun Locho (now marked upon the maps *an Dun*), situated at the head of Loch Killisport on the west side of Knapdale. Conal at this time was evidently ruler over Kintyre, most of Knapdale, and also Jura, Isla, and Colonsay. His two great strongholds were Dun Locho just mentioned and Dun Cholla, or Colla, upon the south of Colonsay.

St Columba was a kinsman of King Conal. He made his first landing in Scotland in A.D. 563 at Port-na-h-Iubhraich on the south of Colonsay. It is only a short distance from Dun Cholla, where Conal at that time appears to have been living. Conal seems to have been anxious to make a good and friendly impression upon the saint, as he gave him camping ground in the little glen almost under the walls of his Dun. He also presented him with the island of Oronsay, which St Columba accepted and at once turned into a sanctuary to which malefactors could flee for refuge. The difficulty was to define when a criminal fleeing from justice was within the bounds of the region of safety, especially as the strand between Colonsay and Oronsay was covered each tide. To make clear

where the sanctuary began and where it ended two crosses were built about half-way across the strand. They were quite different in character, and the safe track from Colonsay to Oronsay passed between them. The cross upon the east side of the road was upright, the sea-worn stump of which still remains built in a foundation of masonry (Plate IX).

The cross upon the west side is built of large loose stones and is prostrate upon the strand, and has remained there as far as is known by tradition for 1365 years. It would not be interfered with by the Columban or the Roman Catholic Church, and certainly not since the time of the Reformation by the Protestant.

When I first visited Colonsay the traditional existence of this cross was known to all the old people, but no one had seen it. No one could tell its exact location, but all said it existed. At first I was confident it would be found, but latterly became doubtful.

For nearly thirty years I kept searching for it when crossing the strand, but made no discovery. One day seeing a large mass of seaweed near the remains of the upright cross I dragged the weed aside, and as the signs seemed hopeful I got a knife and cut the seaweed off, and to my joy found the cross, which was concealed beneath the weed. It was built of large, loose stones now covered with seaweed, barnacles, and *Serpularia* and had upon its surface the markings of many growths of seaweed, principally *Fuci*. These growths, as far as could be judged, seemed to represent many generations of seaweed. From their size and luxuriance the *Fuci* growing upon it evidently belonged not to one year but to a number of years. Some stems were much longer than others which probably meant a difference in age.

For a good many years I have kept this prostrate cross under observation and cut off the weed several times. From what I have seen I judge that it takes from four to six years for the *Fuci* upon the stones of the cross to attain full growth. But even full growth with the ordinary accompanying vesicles will not give the full lifting power which the buoyancy of the weed should cause. This is owing to the shallowness of the sea at full tide at the place where the cross is built, which prevents the stretching and tension of the weed to give the lifting power. However, at certain high tides there has been

at various times sufficient buoyancy to displace some of the smaller stones and turn slightly to one side the lower part of the shaft of the prostrate cross and also the arms.

The depth of water at the cross at high tide, which is situated upon the shallower portion of the strand, is probably not more on average tides than four or five feet, but on occasions may rise to nine or ten feet. The strand is situated in a bay between the islands, and it is only covered by the sea for a few hours each tide, except during gales, when the tide sometimes does not leave the strand dry. However, when the tide is full the current is strong. The bay being to some extent land-locked the waves do not, as a rule, become as violent as at other situations upon the coasts of Colonsay or Oronsay.

Here we have a monument that we know has been exposed to the action of the waves for over 1300 years, and we can see for ourselves the effects of the action of the sea upon it during that long period. The surfaces of its various stones are rough and angular, not like some other stones borne by the seaweed on exposed parts of the Scottish coasts. The difference in the effects of the seaweed upon the stones in tossing them about and grinding and rounding their surfaces while in a buoyant state accounts for what I have observed. The reason for the rough state of the surfaces of the stones of the prostrate cross is that they have been at rest nearly all these years, comparatively free from friction, and at the same time to a large extent protected with their growth of seaweed.

Had they been buoyed up and floated by seaweed to be dashed by the tempestuous seas of the Atlantic Ocean upon rocky shores we would have found rounded stones ground to a smooth surface. The contrast in the effects of the action of the sea upon these two crosses during the long period of years I have mentioned is very striking. The most of the shaft of the upright cross has been worn away by the friction of the current and the passing seaweed and stones combined. The stones of the prostrate cross show comparatively little evidence of friction (Plate IX).

During the time that has elapsed since the building of Dun Cholla (anglicised Colla), and its subsidiary fort, Dunan nan Figean, that guarded the entrance to the strand from Colonsay about the year A.D. 322, there is evidence of an elevation of the land. Dunan nan Figean, that was at one time surrounded

by the sea each tide, is now connected with Colonsay by dry land. What was at one time the landing-place on Colonsay, at the head of the strand is now so shallow at high tide that it is useless for even small rowing-boats. However, the elevation has probably not been more than two or three feet, and may be largely due to blown sand from the strand.

In many parts of Scotland and other parts of the British Isles, especially along their western coast, there are many raised beaches belonging to geological ages. Long stretches of the coastline is formed of cliffs with several ledges or steps (Aoineadhs), being steps between the lower and higher cliffs, indicating more than one period of land elevation. We have beautiful illustrations of this land movement on Colonsay and elsewhere.

The faces of these cliffs are perforated with caves, and along their floors and inner recesses are found many rolled stones. These stones are the implements by which the caves were formed. The caves are invariably carved out along the line of a vein of softer rock than that forming the mass of the cliff. Through the rising of the land the bottoms of many caves are not now reached by the waves, so that the excavating process that went on within them through the action of the sea has long since ceased. The stones now found deposited in the bottoms of the caves are quite inert. When these stones had seaweed attached to them they were made mobile by the waves and became powerful instruments in the work of excavation. When buoyed by the weed and dashed by the waves against the cliffs these stones became effective tools, wearing away and breaking off the softer portions of the rock and excavating along the vein of softer stone (generally some kind of limestone) and forming caves, some of them being of great length and tunnelled far into the cliffs. Beautiful examples of these wonderful caves may be seen to perfection along the west coasts of Colonsay, Islay, and Jura, as well as many other places in Scotland. In the innermost recesses of most caves is a raised beach of rounded stones, and it is upon such places that the ancient inhabitants lived and formed their kitchen middens.



View of several of the spouting Boiling Springs at the bottom of the Boiling Fountain Crater,
Grand Soufriere Valley, Dominica (B.W.I.).

Photograph by Symington Grieve.



Grand Soufrière Valley, Dominica (B.W.I.). Showing rounded stones thrown out by the volcano.

Photograph by William Greve.

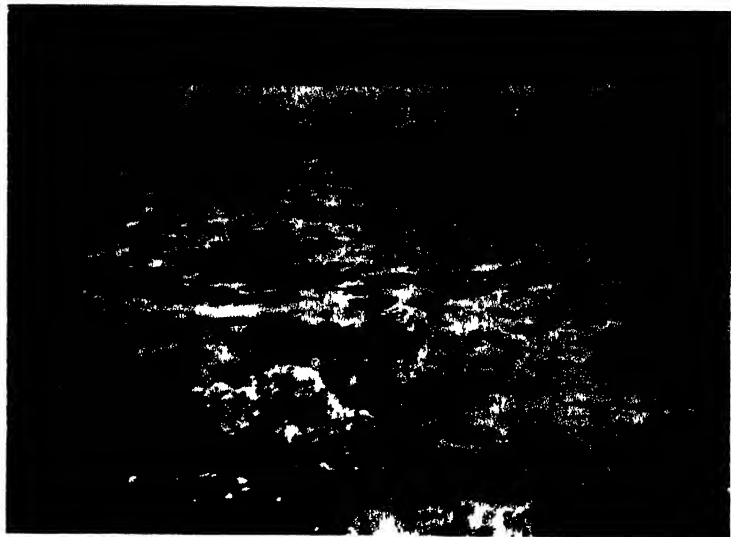


Cheilosiphonia with pebble attached

This seaweed, known as Sea whipcord, grows in long filaments and attaches itself to objects on the bottom of the sea. The specimen illustrated here was wound into a ring when gathered fresh, and only a small part of the plant has been unwound to show the dried filaments with the pebble attached.



Clusters of *Laminaria* holdfasts holding in embrace stones and other material.
Gathered high and dry upon beach of West Knappdale. One-third natural size.



Upright Cross on the strand, Colonsay



Prostrate Cross on the strand, Colonsay

PHYSICAL CHANGES BROUGHT ABOUT BY THE FLOAT-
ING POWER OF SEAWEED. By SYMINGTON GRIEVE.
(With Pl. X.)

(Communication No. 3, read 17th January 1929.)

In my former paper, read in 1880, I referred to what was to be seen of the work of the floating power of seaweed at Ards-kinish, Colonsay. As the place is remote, and never having been there at the time I wrote, I was dependent upon local information. Since then I have been at Ardskinish often, and from my own study of the locality have considerably extended my views regarding the effect of the seaweed-borne stones that are piled high up upon its shores wherever there is a sloping land surface upon which the stones can lodge.

At Ardskinish Farm House, which stands at an elevation of 33·3 feet above mean high-water mark, and even beyond that elevation, are beds of rounded stones that have been conveyed up to that height by the sea. The problem that we have to solve is how that happened. It may be that to some extent the rounded stones owe their present high elevation to a gradual rising of the coastline during a geological period. That, however, can only partly account for what we now find. It appears to me that the evidence all points to a deposit of the rounded stones during all the time the land was being elevated, just as the process is going on now. At times of storm the level may vary many feet from the great height of the Atlantic waves which break with tremendous power along all this coast, especially during gales from westerly directions.

In the first paper of this series, p. 77, which I gave to this Society in 1881, I mentioned from information I had obtained, I was under the impression that the small island that at one time existed off the point of Ardskinish and now forms part of Colonsay, had lost its insularity, through a ridge having been created between it and Colonsay by seaweed-borne stones sinking into the sand. From personal examination I have ascertained that the small island had an elevation of 73·3 feet, while the depression (one time a channel between the island and Colonsay), according to the Ordnance Survey, was only

25 feet above sea-level. The bed of this channel has at one time been much lower. During very high tides or during great storms it is still swept by the sea.

It is filled with loose stones, some of them quite large, that appear to have been floated in by seaweed during western gales. The lower part of the shore at this point is comparatively free from loose stones and long reefs stretch out to sea. Here and there upon them are scattered loose boulders, mostly of considerable size. These boulders lie upon the top of the reefs at present, but were probably brought to where they now are by seaweed. At some future date when they are covered with a great growth of seaweed a storm may arise that will float them high up on the beach.

At other places upon the point of Ardskinish, high up on the shore and above the low line of cliffs that fringe the coast, are large beds of rounded stones. We may ask ourselves the question, How did these stones get there unless floated by seaweed?

Stones with rounded, smooth surfaces when lying upon rocky beds, at or below the level of low tide, are not easily moved by sea waves. However, the same stones when more or less covered by seaweed become buoyant in different degrees and are moved by the wash of the waves. In some cases a stone is floated by the weed and becomes an object tossed at the will of the ocean. Most of the stones deposited upon the point of Ardskinish have come from the west, as the present east side of the point is formed of blown sand. Upon the east side of Ardskinish Point are stretches of sand dunes and a sandy bay named "Traighe na Barca" or "Strand of the Ships." It was at one time used as a harbour.

These rounded stones of different sizes are what may be described as the cores of boulders once of much larger dimensions. The rounding of the stones may have arisen either through the rolling of the stones one upon the other by the action of the waves or through the stones when floated, by seaweed, being chipped and rubbed or dashed by the wash of the waves upon either cliffs or shores.

Possibly the stones may have been lifted by seaweed from some old moraine upon the coast or the deposits at the mouth of some stream. Whatever the cause, the angularities of the stones have disappeared.

In some regions as the west of Colonsay or the Kyle of Lochalsh, where ocean currents are strong and seaweed-borne stones are plentiful, rounded stones form by far the larger portion of the stones found generally lying piled up upon the shore.

There is a difference of opinion as to the cause of these deposited stones being found as they are at Ardskinish, Colonsay, and at Glenelg, in the Kyle of Lochalsh. In the former we have not only the floating power of the seaweed with strong ocean currents, but we have also to take into account the tremendous power of the wash of the Atlantic waves. In the more sheltered Kyle of Lochalsh the waves, although very powerful, cannot compare in force with those of the open Atlantic. However, it is probable that the current in the Kyle is much stronger and is in violent operation every tide. This strong current is, as far as I can judge, acting more rapidly as one of Nature's tools than the current off Colonsay, which runs much slower.

I have given careful study to each of these localities. There are many others in Scotland where the same phenomena can be observed. If we take the whole world, the numbers of places where these physical changes are being effected is so great that the problem is beyond calculation.

When fishing in the Kyle of Lochalsh, if you grab a mass of seaweed as it is swept past the boat by the tide you will be quite surprised to discover what a number of stones are attached to the seaweed and suspended under it and are being floated along, especially at certain seasons of the year.

These stones must come from places upon the coast and prove the large amount of denudation and alteration that is constantly going on through the floating power of seaweed (Plate X).

From observations of the tracks left by the dragged stones upon the sandy mud of the strand between Colonsay and Oronsay it has been found that, although most of these disappear with succeeding tides, some remain, when hardened by a warm sun. These markings or tracks may get covered up with sand by the wash of the waves. However, by geological movements in future ages, they may be discovered and puzzle geologists. The ripple marks preserved on sedimentary rocks are of similar origin.

Another geological mystery may be the finding of erratic stones in sedimentary rocks now beneath the sea. These can be accounted for by the stones having been floated out to sea and the seaweed having lost its buoyancy or having become detached from the stones, which then sank to the bed of the ocean and were covered up with ooze, which in a geological age may become rock.

What I have said has referred to comparatively small stones, and you may be of the impression that any physical changes that can take place, when considered in detail, are only of a minor nature and not worth recording.

However, it is not always so. In time of great storms, such as occur at intervals more or less distant, the operations of the waves, aided by the buoyant power of seaweed, are most amazing. Boulders of immense dimensions, some of them of enormous weight, are tossed up on to ledges or into crevices in sea cliffs, where they remain as evidence of the operation of some wonderful power in nature and puzzling those who see them. If stones can be pitched to such great heights in time of storm, probably the movements of lesser stones to lower elevations and at less stormy times may be very great. Although not easily observed, such movements must be going on continuously. The amount of displacement taking place by the agency of seaweed over the whole world from day to day must be enormous. The nearer the sea-level the greater the movement will be.

I will give you three instances: On the high cliffs on south-west of Colonsay and a short distance south of Port Lobh is a crevice formed by the washing out of a vein of rock, known by the name of the Fians' Staircase. Into this cavity the sea has washed, some distance above the foot of the cliff and about the level of high tide, an enormous, erratic boulder, known locally by the name of the Fians' Putting-stone.

The early inhabitants of Colonsay remarked the stone and associated it with the Fians who once used to visit the island and were supposed to have supernatural powers. The stone is an immense, rounded boulder and has no angularities that could be of much aid to the sea in moving it into its present position. The local tradition is that the Fians putted it from Dungallan across the sea and that it fell where it now lies. My interpretation of the mystery is different, and without the

assistance of the buoyancy of seaweed I am afraid it could never have reached where it at present is.

Sometime after my first paper to this Society was read I had a talk with the late Dr. Joseph Anderson of the Scottish Society of Antiquaries. He told me that he was interested in what I had written as it explained to him some things about which he had been puzzled and about which he was at one time afraid he would not find a solution. Now, he said, he felt he had got some light upon the subject which helped him to form an opinion.

He told me that such violent storms as the one he was about to tell me of only occurred at rare intervals. He was living near Thurso when a terrible storm began, and hearing it was a wonderful sight he ventured out to the cliffs. It was a dangerous expedition, but he felt amply repaid by what he saw.

Immense slabs of stone were being dashed by the waves against the cliffs, some he believed to weigh many tons, and they were thrown up the cliffs fifty to sixty feet where on ledges and crevices some remained. Dr. Anderson told me that some of these great rocks were moved about by the sea as if they were living things, and at the time it was quite beyond his comprehension. He felt sure that these rocks could not be lifted out of the bed of the deep sea unaided in front of the cliffs, even by these angry waves, to be tossed up on dry land. He said he had to confess failure in trying to solve the mystery, until he heard of what I had written about the floating power of seaweed.

Keeping in mind what I have said about how the shape of a stone has much to do with its buoyancy when there is a growth of seaweed upon it, I think we may assume that the stones observed by the late Dr. Joseph Anderson were Caithness flagstones, with large, flat surfaces upon which the seaweed could grow. I do not know the actual specific density of Caithness flagstones, but in all probability it is considerably less than granite. If this is so it would take a smaller quantity of attached seaweed to float these stones.

Most of you have heard of the destruction of Wick breakwater. The structure was built of great blocks of concrete. Year after year, down to 1882, especially in the years 1871 and 1872, the concrete was displaced and the breakwater gradually destroyed. It was supposed that the destruction was caused

by the power of the waves alone. With our present knowledge it would probably be thought necessary to inquire if the agency of seaweed was not at least worth considering as a contributory factor.

The concrete blocks that formed the breakwater are said to have had an immense growth of seaweed upon them. Each surge of the sea would cause the buoyant seaweed to give another wrench to the structure until in course of time it would be weakened. Then the floating power of seaweed would come into operation to move the concrete blocks, thus bringing about the destruction of the building and possibly removing it into deep water, where it would sink beneath the sea. I understand that since its destruction a shorter breakwater has been constructed upon a different plan.

I am afraid that even after what I have told you some will be sceptical. However, when you know how it all comes about, and the explanation is easy, I think you will be convinced. The solution of the mystery is the difference in the specific density of things. Water is the standard of density. The gramme is the unit of weight of a cubic centimetre of distilled water at 4° C. The specific density of a body is the number of grammes-mass per cubic centimetre. There is a great difference in the buoyancy of a stone when immersed in water and when out of water. We all know that a bare stone sinks in water, but few think how little buoyant power is required to make that stone float. For instance, the specific density of granite is 2·5 to 2·9, and most of the rocks found upon our coasts are granitic in their nature and will not vary very greatly from that specific density. Some may be a little lighter, some a little heavier, but I think that for stone granite is a good illustration, as it is of greater specific density than many rocks. It has been with similar rocks that we have been considering the subject, and it is fair to accept this material which has been actually seaweed-borne to aid us in forming conclusions.

Some substances, such as certain kinds of wood and other vegetable matter, float upon the surface of water and therefore are of fractional density, while others, such as various metals, are of much greater specific density than stone and would require probably something more buoyant than seaweed to keep them afloat.

You will at once observe that it takes a comparatively small amount of attached seaweed with bladders to counterpoise the density of the stone, and to change, while this attachment lasts, a stone from a thing that will sink in water to one that will float. Asbestos has the peculiar property that it sinks as a stone when taken from the quarry, but when finely shredded it floats. One of its varieties, named Rock-cork, also floats.

Mr. E. J. Dunn in "Pebbles," p. 67, pl. 60 (Melbourne, 1911), gives a photograph of a pebble of volcanic ash, four inches long, that was floated ashore in Mercury Bay, North Island of New Zealand, with Bladder-wrack, a seaweed, growing upon it. This is much less wonderful than that a granite stone can be floated. The specific density of the volcanic ash would be only about 0.84.

In considering this question of the floating power of seaweed it is necessary to remember that upon the shores of some freshwater lochs, especially large lochs, there are beds of rounded and water-worn stones. These stones are, however, generally much more angular in form than those found upon seashores, washed there by ocean currents. On the shores of freshwater lochs these deposits of rounded stones are partly formed by the action of weathering and the action of the waves combined. Most of these stones are coated more or less by a growth of freshwater algae, the buoyancy of which may be an important factor when associated with prevailing currents and winds in determining the form as well as the position of such stones upon a shore. The growth of algae upon these stones is not much noticed until during periods of drought, when the level of the water in the different lochs or rivers is low and the algae is seen peeling off the stones, generally, as a grey or whitish skin. Such forms of algae seem incapable of floating stones, but have a certain amount of buoyancy which helps to counterpoise the specific density of a stone and makes it easily moved by the waves or currents. In this way beds of stones may be formed, and where the water is shallow often become exposed to the sun when a loch or river is low, and it is then that the stones have the bleached appearance above referred to and the stones appear to skin. These rounded stones are seldom, if ever, found piled up upon the shores of freshwater lochs. In Loch Awe, Argyllshire, beds of stones

more or less rounded occur, but it is believed that they mark the sites of lake dwellings (Crannogs). Originally the rounded form of these stones may be to some extent due to volcanic action, such as burst open the pass of Brander.

In 1880 I wrote a paper which appears in the "Proceedings of the Edinburgh Botanical Society" (pp. lviii-lxii, session 1880-1881). This paper created some discussion at the time, but as far as I know seems to be forgotten, and perhaps none of you ever heard of it. Early in the spring of 1882 I heard it was a subject that interested the late Charles Darwin. I sent him a copy of my note, but was unaware that he was then very ill and unable to leave his room. I have been told that at the time he received my letter and note he was so prostrate that he could only be lifted to a couch from his bed to have it made. Notwithstanding the critical state he was in he wrote me on 22nd March 1882 as follows :—

DOWN, BECKENHAM,
KENT.

DEAR SIR,—The subject of your essay would, I think, be well worth pursuing.

I have long known that stones were transported by floating Fuci, but I cannot remember my authority ; perhaps cases are given by Lyell. It is, however, quite new to me that stones are thus dragged along the bottom leaving a trail behind them.—I remain, dear sir, yours faithfully,

(Sgd.) CH. DARWIN.

SYMINGTON GRIEVE, Esq.,
Edinburgh.

I had written to Charles Darwin asking if he thought I should continue my study of the subject. His answer was decidedly encouraging. He literally wrote me from his death-bed, as he died on 19th April 1882, at the age of seventy-three, having been born on 12th February 1809. He was buried in Westminster Abbey.

This unpublished letter shows his desire to help with his enthusiasm and sympathy a humble fellow-worker in the pursuit of science.

I must have known many years ago what Darwin had written in "The Voyage of the Beagle" about erratic stones found on coral atolls (Colonial and Home Library edition, xii, 461). I had quite forgotten until Mr. R. G. Thin recently drew my

attention to the passage, which refers to Keeling Island and its neighbourhood, and is as follows :—

“ A few miles north of Keeling there is another small atoll, the lagoon of which is filled up with coral mud. Captain Ross found embedded in the conglomerate on the outer coast a well-rounded fragment of greenstone, rather larger than a man's head : he and the men with him were so surprised at this that they brought it away and preserved it as a curiosity. The occurrence of this one stone where every particle of matter is calcareous, certainly is very puzzling. The island has scarcely ever been visited, nor is it probable that a ship had been wrecked there. From the absence of any better explanation I came to the conclusion that it must have become entangled in the roots of some large tree. When, however, I considered the great distance from the nearest land, the combination of chances against a stone thus being entangled, the tree washed into the sea, floated so far, then landed safely, and the stone finally so embedded as to allow of its discovery, I was almost afraid of imagining a means of transport so improbable. It was, therefore, with great interest that I found Chamisso, the justly distinguished naturalist who accompanied Kotzebue, stating that the inhabitants of the Radack archipelago, a group of lagoon islands in the midst of the Pacific, obtained stones for sharpening their instruments by searching the roots of trees which are cast upon the beach. It will be evident this must have happened several times, since laws have been established that such stones belong to the chief, and a punishment is inflicted on anyone who attempts to steal them. When the isolated position of these small islands in the midst of a vast ocean, their great distance from any land excepting that of coral formation—attested by the value which the inhabitants, who are such bold navigators, attach to a stone of any kind—and the slowness of the currents of the open sea, are all considered, the occurrence of pebbles thus transported does appear wonderful.

“ Stones may often be thus carried ; and if the island on which they are stranded is constructed of any other substance besides coral they would scarcely attract attention and their origin at least would never be guessed. Moreover, this agency may long escape discovery from the probability, of trees, especially those loaded with stones, floating beneath the surface.

In the channels of *Tierra del Fuego* large quantities of drift-timber are cast upon the beach, yet it is extremely rare to meet a tree swimming on the water. These facts may possibly throw light on single stones, whether angular or rounded, occasionally found embedded in fine sedimentary masses."

In a footnote Charles Darwin mentions "that some natives carried by Kotzebue to Kamtschatka collected stones to take back to their country." The use of the stones was to sharpen tools or weapons.

The foregoing is very interesting, but all Charles Darwin's difficulties would have been solved had he known at the time he wrote about the floating power of seaweed. As to the fragment of greenstone found by Captain Ross, it was probably conveyed to where it was found by the buoyancy of *Fucus*, while the small pebbles would be conveyed to the coral atolls grasped in the roots of *Laminaria* or some similar seaweed, which in some parts of the Pacific grow to an immense size and to the savage people would be known as trees. As to the theory of the roots of trees grown on land carrying stones, it must be applicable as far as rooted and sea-borne trees are concerned to only a very limited extent. It is quite true that at times trees that have been blown down, or fallen from undermined banks, carry embedded among their roots a large quantity of earth and gravel, and on rare occasions larger stones. The way this material is embedded among the roots makes it easily washed out. It is evident that to be carried great distances at sea there must be some other agency to convey stones as Charles Darwin realised, although he did not know what it was. To convey stones anywhere at sea, trees would have to float. This of necessity would, whether upon the surface or just below the surface, expose the trees to the action of the ocean waves, and all material carried among the roots would soon be washed out through the law of inertia giving resistance to the waves. The solution of the question seems to be that what the natives called tree roots were the roots of *Laminaria*. There is no doubt that when growing the roots of *Laminaria* envelop all kinds of objects upon a sea bottom, and that the attachment is secure until the root of the *Laminaria* either rots off or dries off.

I have searched Sir Charles Lyell's books, but I have been

unable to find any reference to physical changes caused by the floating power of seaweed.

Lyell says much about the wonderful action of ice, but seems to have been unaware that floating seaweed could effect physical changes upon the earth. At pp. 280-281, "Antiquity of Man," referring to erratic blocks upon the southern coast of Sussex, he says: "These blocks are to be seen in greatest numbers at Pagham and Selsea, fifteen miles south of Chichester, lat. $50^{\circ} 40'$ N. They consist of fragments of granite, syenite, and greenstone, as well as Devonian and Silurian rocks. . . . They were probably drifted into their present site by coast ice, and the yellow clay and gravel in which they are imbedded is a littoral formation as shown by the shells." Lyell does not say definitely that these stones were conveyed to their present site by ice, he uses the word "probably." However, he says they are embedded in a littoral formation among shells, and this statement arouses suspicion that Lyell may have been mistaken as to the agency that brought these stones to their present situations. This matter needs further investigation. Geikie in his "Textbook of Geology" (4th edition, ii, 1016) points out that "there occur in different parts of the carboniferous system scattered pieces and even blocks of granite gneiss, quartzite, or other durable material which lie embedded, sometimes singly, sometimes in groups, in limestone, sandstone, and in coal." Various explanations have been proposed to account for these erratics. Some writers having even suggested the action of drifting ice. The stones were most probably transported by floating plants. Seaweeds, like our living *Fucus*, with their rootlets wrapped round loose blocks, might easily be torn up and drifted out to sea, so as to transport and drop their freight among corals and crinoids living on the bottom.

Ice, snow, and rain have been important factors in altering land surfaces and effecting physical changes. However, we can hardly say in Scotland that we are now living in the Ice Age, although it operates farther north. The physical changes are still going on although on a diminished scale. The probability seems to be that at some distant dates more than one Ice Age may recur when rapid changes in denudation may take place in the northern hemisphere, just as they are, in all probability, now taking place in the southern.

The changes caused by the floating power of seaweed are always actively taking place over all parts of the world where seaweed grows, in the tropical, sub-tropical, and temperate zones. The areas thus affected are much greater than the Arctic and Antarctic regions, and probably the changes are proportionally great although as yet little observed.

A thought that naturally suggests itself is—Will it ever be possible to utilise the power connected with the floating power of seaweed? It is a difficult problem, one that may prove insoluble, but yet seems to have potent possibilities. Much research and study may be required, but it seems likely it will be found that to supply power in connection with the floating power of seaweed ocean currents must contribute the primary force. To anyone with knowledge of the subject the potentialities of an ocean current are awe inspiring.

The resistance caused, especially in narrow channels, by the presence of vast masses of floating seaweed would augment the power, and that power would again be greatly increased when such floating seaweed was weighted with attached stones.

On Thursday, 14th March 1929, Dr. James Clark delivered a lecture upon the Scilly Isles to the members of the Botanical Society, in the large hall at the Royal Botanic Garden, Edinburgh. He referred to certain phenomena he had observed but could not satisfactorily explain. In answer to a letter that I wrote him he kindly sent me the following, which is very interesting and an important record well worth preserving:—

“I had two experiences in the Isles of Scilly of the bombardment of rocks by sea-thrown blocks of stone. The first was on White Island to the north of St. Martins and accessible on foot at low water. On the eastern side of this is a narrow inlet called Chad Girt, about 100 yards long, between high, irregular walls of rock; there was a fresh breeze blowing from the south-east and the sea was rushing into this gap like a tremendous torrent and throwing great boulders against the upper part of the inlet. Some of these blocks must have been several feet in diameter and we noticed at the time that several carried a big tuft of seaweed.

“The other occasion was the one mentioned in my lecture and took place at Round Island, a precipitous islet to the north of Tresco, crowned with a lighthouse. A stiff wind was

blowing in the morning which by the afternoon had developed into a fierce south-westerly gale with a velocity estimated on Tresco at sixty-five miles per hour. The bombardment was first noticed about two hours before high-water and rapidly increased in violence till the rocks at times seemed to vibrate with the shocks. I have no idea how big the blocks were, but only those of a very large size could have created the disturbance they did."

In his lecture Dr. James Clark informed his audience that the rock at the Round Island was all granite.

There may be more factors than one in operation, but you will find it well worth your while to give some thought and study to the floating power of seaweed.

FLOATING POWER OF ASCIDIANS.

Since writing the above, Professor J. H. Ashworth, F.R.S., of Edinburgh University has been so kind as to send me a short note by Professor Charles Chilton, M.A., D.Sc., etc., of Canterbury College, New Zealand, that appeared in the Transactions of the New Zealand Institute (vol. 56, pp. 523-524), upon the "Dispersal of Pebbles and Marine Organisms," issued 26th April 1926.

This paper refers to the power of free-swimming larvae, of an ascidian *Boltenia pachydermatina*, Herdman, to attach itself to pebbles to grow upon them and on occasion to lift them from a gravelly bottom. In stormy weather these ascidians are thrown upon certain shores in numbers with pebbles attached. This is probably due to the great numbers of *B. pachydermatina* that grow upon gravel beds in shallow seas. In other localities single pebbles with *B. pachydermatina* attached are found. The *Boltenia* has stalks of from twelve to fifteen inches in length when full grown. Many stems grow upon each pebble, and each stem has a certain amount of floating power—in the aggregate there is a considerable amount of buoyancy. The stalks and other organs of the ascidians probably have a number of air-vessels in their stems, just as we find air-vessels in the stem of the sea-whipcord, *Chorda filum*.

Some, if not all, of the pebbles mentioned by Professor Charles Chilton seem to have been carried long distances,

but none of them are large and the heaviest is said to have weighed only half a pound. This particular pebble was found at Riverton Beach, south coast of New Zealand. It is



Pebble with stalked Ascidians attached.

This drawing was prepared by Miss Beryl Parlane, a student of Professor Charles Chilton, M.A., D.Sc.

rather flat and is probably beach worn ; it measures 3 in. by 2½ in. by 1½ in. I am enabled to give an illustration, the learned Professor having kindly supplied the printing block. Other smaller pebbles seem to have come from rivers and been washed into the sea where the ascidians grew upon them. Two correspondents of Professor Charles Chilton are



Seaweed borne stones with seaweed attached from the shore (Glenc
Kyle of Lochalsh



Same stones after being brought to Edinburgh and kept some time
Weights — 1 lb 10 oz 2½ lb , 3 lb 14 oz 6 lb 2 oz , 6½ lb 18½ lb

quoted by him, namely, Mr. John Hardcastle of Timaru and Mr. C. D. Gilling also of Timaru. The former mentions the washing ashore, after a succession of southerly gales in 1912 along many miles of shingly beach south of Timaru, of a large quantity of stalked ascidians which had grown in bunches, usually to the number of twenty or more to each bunch. A small proportion of them brought ashore pebbles entangled among their holdfasts.

Mr. C. D. Gilling tells of the frequent stranding of many ascidians on the shingly beach north of Timaru. He sent many specimens to Professor Charles Chilton which were attached to smooth river- or beach-worn stones, most of which were much smaller than the one found at Riverton.

In the aggregate these small pebbles, when floated along coasts and allowed to accumulate for long periods, may effect physical changes. However, the action of the floating power of seaweed must, as far as our present knowledge goes, be considered a very much more important factor.

I have no doubt there is much still to discover about the physical changes that may be brought about by the floating power of seaweed. By drawing attention to the subject I trust that I may have interested some of you and that further discoveries will result.

THE STRUCTURE OF CERTAIN PORICIDAL ANTHERS.

By J. R. MATTHEWS and C. M. MACLACHLAN.

(Read 14th February 1929.)

The structure of the anther showing longitudinal dehiscence has been the subject of numerous investigations, and various workers have advanced different views regarding the actual mechanism involved. These have been conveniently summarised by Haberlandt (1914). Chatin (1870) gives a comprehensive survey in his classical paper on the anther, and combats the theory put forward by earlier investigators that dehiscence is in all cases due to the hygroscopic movements of the fibrous layer. An important part of Chatin's work is his demonstration that in a considerable number of flowering plants this fibrous layer is absent, and he assumes that in these cases, as also in forms having a normal fibrous layer, the several other tissues of the anther wall may be functional in effecting dehiscence. In this connection he states that the absence of a fibrous layer is frequently, though not constantly, associated with dehiscence by terminal pores, but the latter phenomenon he dismisses in a brief paragraph, distinguishing two types which he designates "false porose" and "true porose." The former is referable in its mechanism to ordinary longitudinal dehiscence, while the latter depends upon the destruction of tissue at a given point. Leclerc du Sablon (1885) rejects Chatin's view regarding the rôle played by the fibrous layer in bringing about longitudinal dehiscence, and while he recognises the two types of porose dehiscence, he challenges the statement that the feature is generally associated with the absence of a fibrous layer, and also the common belief that the true porose type is the more prevalent. He states that in the majority of cases dehiscence by apical pores is essentially a localised longitudinal dehiscence resulting from the drying and differential shrinkage of a fibrous layer which is frequently restricted to the apex, but not uncommonly extends the whole length of the anther.

Recent work on anther structure shows that even within the limits of a single family actual anthesis may be effected

in different ways. Details have been given by Namakawa (1919) for the Solanaceae, by Ziegler (1925) for the Melastomaceae, and by Matthews and Knox (1926) for the Ericaceae. In these families porose dehiscence of the anther is of frequent occurrence, but the formation of the pore and its mode of opening are by no means similar throughout. In the present paper an account is given of four species which possess porose dehiscence, the examples having been selected from widely separated families: Melastomaceae, Tremandraceae, Leguminosae, and Ochnaceae.

TIBOUCHINA SEMIDECANDRA Cogn.

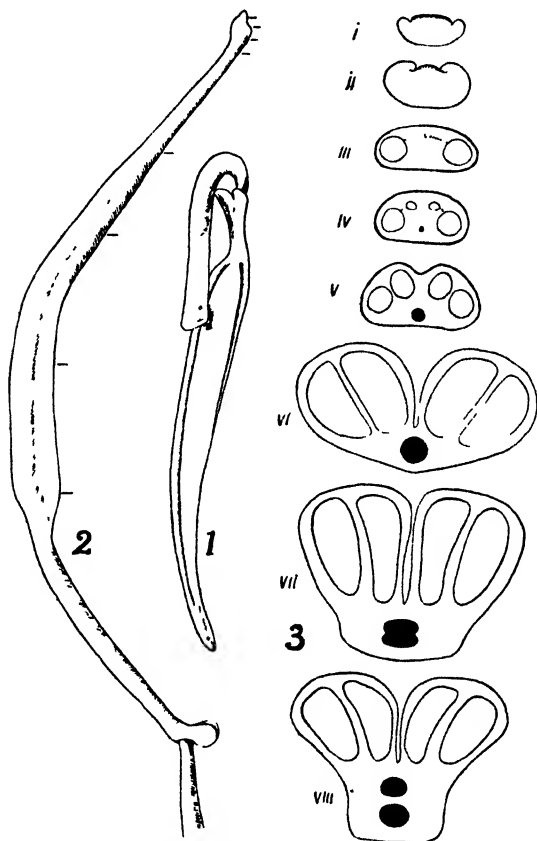
A member of the Melastomaceae, this plant is a small tree bearing large purple flowers singly in the axils of the uppermost leaves or in terminal inflorescences. The androecium consists of ten stamens, which in the young flower are bent downwards due to a curvature of the filament, and the anthers fit into long pits in the wall of the torus (fig. 1). As the flower opens the filaments straighten and the anthers assume a more or less horizontal position. The filament is slender, about 2.5 cm. long, and to this the slightly curved anther is hinged (fig. 2). The hinge permits those remarkable changes in position which are assumed by the anther during the opening of the flower.

In its lower half the anther is distinctly bilobed, but distally it becomes considerably narrowed and the bilobed structure disappears (fig. 3, i-viii). Of the four pollen sacs the dorsal pair are slightly the longer, and the apex of the anther constitutes a short, sterile prolongation of the connective which becomes conspicuously inflated in the mature stamen. Dehiscence is effected by the formation of a pore which develops on the ventral side of this distal prolongation. While the pore is really lateral in origin it is restricted to a position so near the tip of the anther as to be described usually as apical.

A single vascular strand ascends the filament until near the joint, where it branches to form two laterals. These soon approximate, and two strands enter the connective at the base of the anther (fig. 3, viii). These then unite to form a single vascular tract, which passes upwards to the limit

of the ventral pollen sacs. The extreme apex of the anther is thus devoid of vascular tissue.

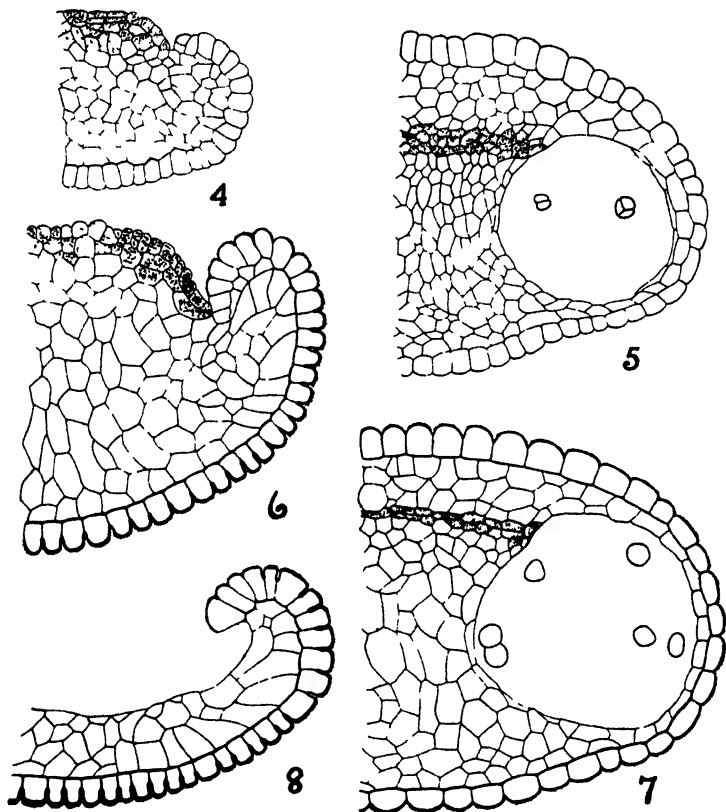
In the young stamen the point of dehiscence is marked by a circular plate of tissue delimited by a fairly deep groove



FIGS. 1-3.—*Tibouchina semidecandra*. Fig. 1, young stamen showing curvature of filament ($\times 20$); fig. 2, side view of fully expanded stamen ($\times 20$); fig. 3, a series of transverse sections of anther numbered from apex to base, the sections corresponding to the levels marked in fig. 2. In figs. 1 and 2 only a portion of the filament is shown.

(fig. 3, i and ii). A transverse section through this region is shown in fig. 4, half of the section being drawn. On the dorsal side the epidermis consists of a regular layer of slightly radially elongated cells, while on the ventral side the epidermal and hypodermal layers consist of rather small, irregular cells having thin walls, dense protoplasmic contents, and large

nuclei. This tissue marks the position of the pore, and by its ultimate disintegration the pore is formed. It is similar in appearance to the tissue of the pore area in some *Ericaceae*,



FIGS. 4-8.—*Tibouchina semidecandra*. Fig. 4, transverse section through apex of anther showing structure of the pore area before dehiscence; fig. 5, transverse section of young anther cut below the level of the pore, showing one of the dorsal pollen sacs and resorption band; fig. 6, section through the pore area at a later stage than that shown in fig. 4; fig. 7, same as fig. 5 at an older stage; fig. 8, transverse section through apex of mature anther after dehiscence. All figures are $\times 205$, and only the half anther is shown in each figure.

and may be called resorption tissue. Below the level of the pore the resorption tissue ceases to be superficial. Traced downwards through the sterile apex of the anther it gradually becomes more deeply seated, until at the upper limit of the dorsal pollen sacs it appears as a narrow band traversing the

connective between the sacs (figs. 3, iii, and 5). At a lower level the continuity of the band is broken by the development of the ventral pair of sacs, but here segments of it persist, serving to connect the four sporangia. It is only in the upper part of the anther that this disjunctive tissue develops, marking the position of the future pore, and extending down the anther just far enough to connect with the four pollen sacs.

As the anther matures the most noteworthy change is the thickening of the epidermis. At the pore level the cells on the dorsal side become papillose, develop relatively thick outer and inner tangential walls, while the radial walls remain thin. The cuticle is well developed and is minutely papillose. The resorption tissue of the pore area and the epidermal cells covering it remain thin-walled (fig. 6). Below the level of the pore the epidermis forms a complete layer of somewhat flattened cells with thickened outer walls (fig. 7).

Dehiscence of the anther is due primarily to the shrinkage and disintegration of the thin-walled resorption tissue, which commences first within the pore area. The absence of a thickened epidermis on the ventral side, where the opening occurs, will encourage this shrinkage as the anther matures and the tissues begin to dry. But the extensive dissolution of the soft parenchyma which eventually occurs suggests also the action of enzymes. In the upper part of the anther the septa between the pollen sacs break down, so that an open channel is established between the sacs and the exterior, allowing for the gradual liberation of the pollen. The structure of the open pore is shown in fig. 8. Finally, little remains save the framework formed by the thickened epidermis on which rigidity of the tip of the anther depends. The peculiar inflation at the tip is caused by the breaking or folding of the thin radial walls of the epidermal cells, allowing the convex, outer tangential walls to expand. The open pore thus forms a small sac or pocket at the apex of the anther, within which pollen grains may collect.

Dehiscence in *Tibouchina semidecandra* appears then to be of the true porose type, and is essentially similar to *Medinilla* and other forms described by Ziegler, being due mainly to the destruction of a previously prepared tissue, and not to any mechanism located in a hypodermal fibrous layer. In fact,

no mechanical layer is formed, the sub-epidermal layer being indistinguishable from the underlying tissue.

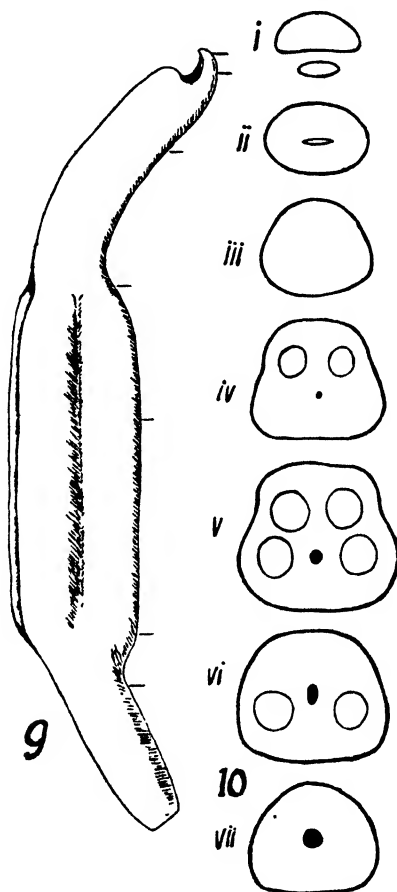
TETRATHECA PILOSA Labill.

This is a small ericoid shrub belonging to the family Tremandraceae. The general structure of the stamen in this family has been described by Chatin (1870, 1874) and by Chodat and Balicka (1893), but no full account of any species is given. The flowers in *Tetralthea pilosa* are solitary and axillary, borne on short pedicels on the ultimate branches of the plant. They are usually pendulous, but may become more or less horizontal due to crowding. The general form of the androecium and the structure of the stamen assume a greater biological significance, however, in the normal pendulous position of the flower. The androecium consists of eight stamens forming a close ring round the ovary, over which the inwardly inclined tips of the anthers approximate to form a "cone of dispersion," recalling the arrangement seen in *Galanthus*, *Cyclamen*, some of the Boragineae, most Ericaceae, and some other forms with pendulous flowers.

The stamen is blackish-purple in colour, becoming paler distally and colourless at the tip. A stout filament bears the basifixed anther, which is about 3 mm. long, consisting of a basal fertile part and a distal, sterile portion 1 mm. in length (fig. 9). The vascular supply is a single strand passing through the filament and connective as far as the upper limit of the ventral pollen sacs, which are slightly longer than the outer pair. There is no vascular tissue in the distal prolongation of the connective.

At the apex of this sterile column are two unequal lobes, and it is between these that a circular pore is established when anthesis takes place (figs. 10, i, and 11). Lower down the lobes unite laterally to form a circular structure as seen in transverse section, enclosing a narrow slit whose boundaries are the epidermal layers of the inner surfaces of the lobes (figs. 10, ii, and 12). The slit is present at a very early stage, and is intimately connected with the opening of the ripe anther. At a lower level the adjacent surfaces of the slit approximate and ultimately fuse to form the solid column of tissue surmounting the fertile portion of the young anther.

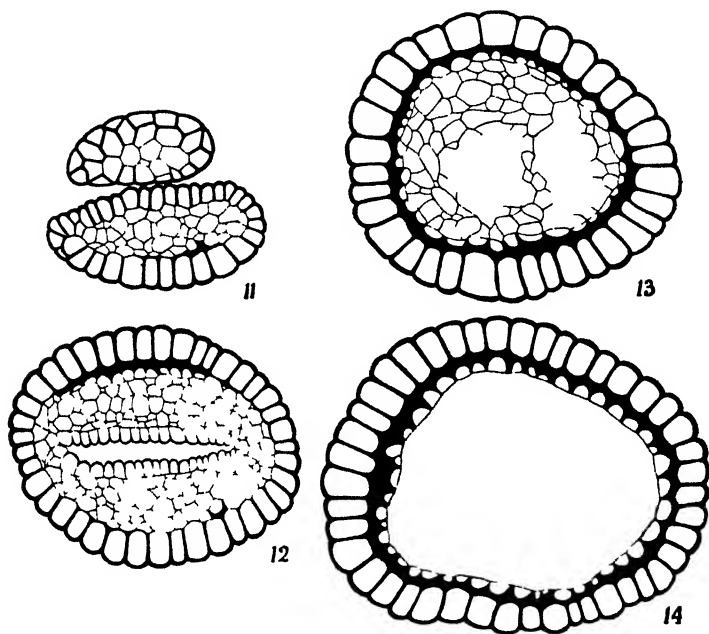
As maturation proceeds the epidermal cells undergo conspicuous thickening, especially on the outer tangential and radial walls (fig. 11). Where the lobes have fused, the hypo-



FIGS. 9 and 10.—*Tetratheca pilosa*. Fig. 9, side view of stamen showing distal prolongation of anther, which forms the pollen-conveying tube and terminal pore ($\times 33$); fig. 10, a series of transverse sections through a young stamen numbered from apex to base, the sections corresponding to the levels marked in fig. 9.

dermis, especially on the dorsal side of the structure, also shows pronounced thickening, forming a rigid plate in that part of the apex where dehiscence eventually occurs (fig. 12). Lower down the thickening of the hypodermal layer extends completely round the structure, and forms a strong, sclerotic

ring surrounding the pollen-conveying tube in the upper sterile part of the anther (fig. 13). In the region of the slit (fig. 12) the cells of the inner epidermis undergo thickening of the outer walls with a finely papillose, cuticular development, the thickening extending slightly to the radial walls. But at the corners of the slit the cells remain thin-walled. Accompanying



FIGS 11-14 — *Tetratheca pilosa* Fig 11, transverse section through apex of anther showing the two rigid lobes which terminate the anther, fig 12, transverse section through the region of the pore before dehiscence, fig 13, transverse section through the sterile distal prolongation of the anther, the central parenchyma disintegrating to form a cylinder, the completed stage of which is shown in fig. 14 (All figures $\times 150$.)

these changes there is an accumulation of dense, granular material especially in the cells of the hypodermal layer. This material stains deeply, and may play some part in those subsequent changes which lead to anthesis.

Preparatory to the opening of the anther the soft parenchymatous core of the sterile column begins to disintegrate (fig. 13). This dissolution of tissue proceeds until an open channel is formed, as seen in fig. 14, leading from the pollen sacs upwards to the base of the slit. In the region of the

slit, however, there is little destruction of tissue. The thin-walled parenchyma undergoes shrinkage, which causes breaking of the tissue at the corners of the slit, and the two opposed inner surfaces are gradually pulled apart. The actual outlet for the pollen, at first appearing as a very narrow slit, thus becomes an open pore lined with a well-developed epidermal covering.

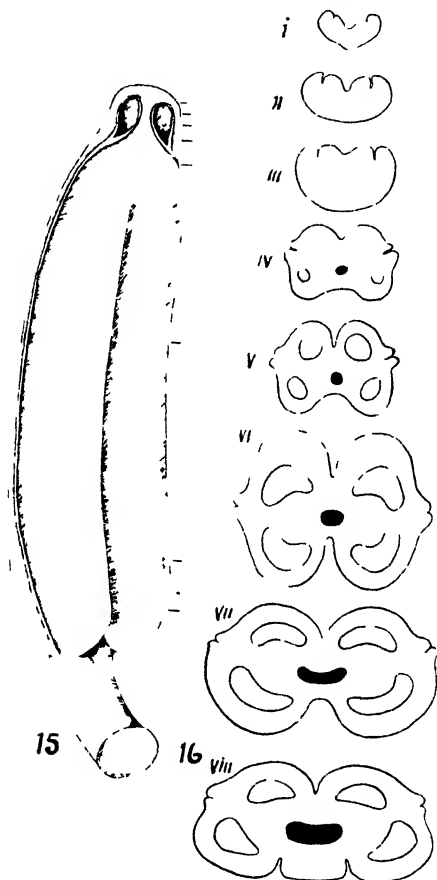
Two distinct processes appear to play a part in the opening of the anther in *Tetralthea pilosa*, the first, probably chemical in nature, brings about the complete destruction of the internal tissue of the distal prolongation to form a pollen-conveying tube, and the second, the shrinkage of tissue in the apical part of the anther surrounding the slit which controls the final exit of the pollen. There is no active hygroscopic layer either in the epidermis or in the hypodermis. These tissues give mechanical rigidity to the device for pollen presentation, and it is clear that anthesis here does not conform strictly to either of the two types of porose dehiscence described by previous workers.

CASSIA AUSTRALIS Sims

This plant, a member of the Leguminosae (Caesalpineae), is a small shrub bearing few-flowered, lax inflorescences in the axils of the uppermost leaves. The flowers are generally horizontal, but the stamens bend towards the anterior side of the flower and assume a horizontal position independently. The ontogeny of the flower has been investigated by Thompson (1925), who reports that the development in *Cassia australis* is fundamentally the same as in *Cassia Fistula*, which he describes in detail. Chatin gives an account of the anther structure in a few species, but no reference is made to *C. australis*, which seems to possess features of special interest.

The general form of a stamen is shown in fig. 15. The filament is short and stout and the anther basifixed. The anther is markedly bilobed, each lobe having two sporangia, which extend from the base almost to the apex, the two dorsal sporangia being slightly the longer (fig. 16). Dehiscence is by means of two small sub-apical pores on the ventral side of the anther. From the base of each pore a conspicuous groove runs along the whole length of each lobe, and is very suggestive of a longitudinal suture.

In the young anther the apex consists of a solid cone of tissue, roughly hemispherical, as seen in transverse section, showing on the ventral side the two grooves already referred to (fig. 16, i, ii, iii). These grooves mark the future points



FIGS. 15 and 16.—*Cassia australis*. Fig. 15, general view of anther showing apical slits and longitudinal furrow ($\times 15$); fig. 16, a series of transverse sections through a young anther taken at levels indicated in fig. 15.

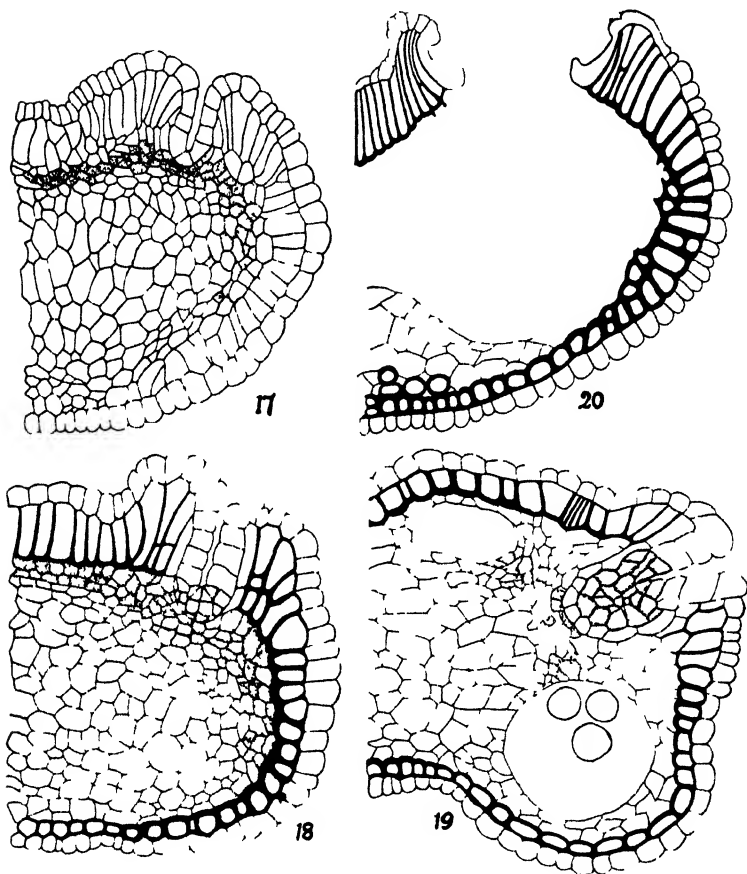
of dehiscence. The detailed structure of this area is shown in fig. 17. The epidermis forms a regular layer lining the grooves and delimiting the whole structure. On the ventral side the hypodermis consists of large, radially elongated cells, except in the region underlying the groove. On the dorsal side the hypodermal cells are isodiametric. The general

matrix of tissue within shows several layers of small cells below and extending laterally from the groove, which are characterised by dense protoplasmic contents. This tissue is the first to undergo disintegration preparatory to the opening of the pore, and it may therefore be referred to as the resorption tissue.

Growth and maturation of the anther is accompanied by marked thickening of the hypodermal cells (figs. 18 and 19). Those cells placed laterally to the stomial groove are thickened on their inner tangential and radial walls, like the annulus cells in a fern sporangium, and occasionally fibrous thickenings are laid down. The smaller hypodermal cells bordering the connective tissue, however, are uniformly thickened. In the pore area (fig. 18) there is no thickening of the hypodermis immediately below the stomium, for there the cells form part of the disjunctive tissue. A remarkable feature is the behaviour of the epidermal cells at the base of the groove. These undergo division to form a plug of small, thin-walled parenchyma, which completely fills the pocket at the bottom of the groove (fig. 18). This parenchymatous plug is even more fully developed below the apical part of the anther, and it extends throughout the length of the fertile portion, filling up the base of the longitudinal furrow (fig. 19). Beneath this pocket of cells the hypodermis forms a band of somewhat thickened cells sharply separating the enclosed parenchyma of the groove from the underlying tissue of the septum between the pollen sacs. The clamp thus formed runs the whole length of the anther, being absent only from the short, sterile apex where the pore develops. It should also be noted that in the lower part of the anther (fig. 19) the thickened hypodermis consists of cells which are less elongated radially than the corresponding cells in the pore area.

Dehiscence of the anther is preceded by disintegration of the resorption tissue underlying the stomium and lower down in the partitions separating the pollen sacs. In the pore area all the resorption tissue and the adjacent thin-walled parenchyma eventually break down. In this dissolution of tissue the small cells of the stomium are involved, and a fairly wide gap is formed by the continued contraction of the hypodermis functioning as a hygroscopic layer. The restriction of the pore to the apex of the anther is largely due to the clamp

formed by the hypodermis underlying the longitudinal groove throughout the lower part. In the dehiscent anther the plug



FIGS. 17-20.—*Cassia australis*. Fig. 17, transverse section through apex of anther lobe in the region of the apical slit showing deep suture and resorption tissue; fig. 18 shows a later stage of development in the pore area; fig. 19, transverse section of anther lobe below the place of dehiscence showing disintegration of tissue between the pollen sacs and clamp formed by hypodermis round the suture, fig. 20, transverse section of anther lobe after dehiscence. (All figures $\times 164$.)

of epidermal cells which block the groove disappears, but the clamp persists and bridges the gap.

The mode of dehiscence is here apparently twofold, involving the destruction of tissue at a given point and the subsequent tangential shrinkage of the hypodermal layer at the same

point. While the hypodermis certainly operates as a mechanical layer, it probably only serves to widen a slit already produced by the disappearance of the resorption tissue and the cells forming the stomium. The view may be advanced that in *Cassia australis* dehiscence of the anther by short sub-apical slits is associated with the loss of a completely functional endothecium and the presence of specially prepared disjunctive tissue in the region of the pore. Moreover, both epidermis and hypodermis along the line of the longitudinal sutures behave in a remarkable way.

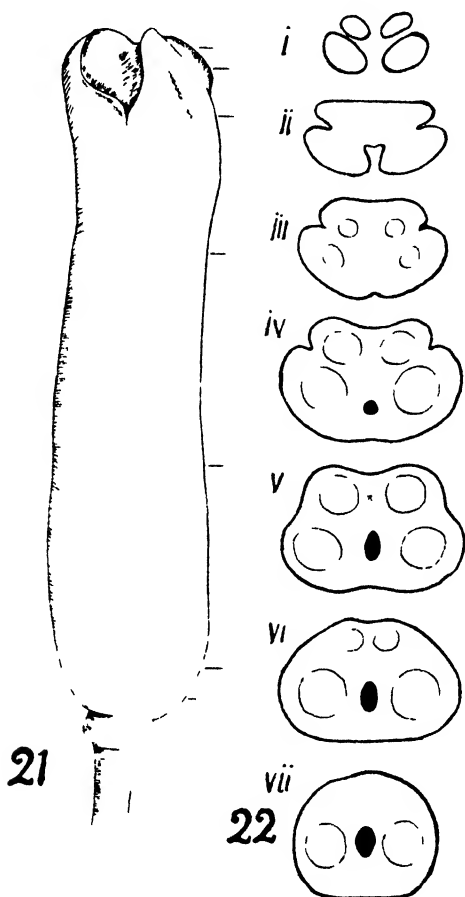
OCHNA SERRULATA Walp.

This is a small shrub belonging to the family Ochnaceae, bearing bright yellow flowers in the axils of the leaves of the ultimate branches. The androecium consists of numerous stamens, the general form of the stamen being shown in fig. 21. The anther is basifixed and dehisces by two short apical slits. The pollen sacs extend almost the whole length of the anther, but the two inner sacs do not reach the base, and all four end just below the apex.

In the young stamen the upper part of the anther is bilobed, each lobe having two lateral grooves which mark the place of dehiscence, but lower down the stomial grooves gradually become eliminated (fig. 22). The development of the anther, especially at the apex, follows a fairly normal course. Details of structure prior to opening are shown in fig. 23. The epidermis consists of relatively thin-walled cells, and those which define the stomium are small. The hypodermis differentiates to form a characteristic fibrous layer, save a few cells underlying the stomium, which are small and unthickened. In the layer below the hypodermis, Chatin's "third membrane," some of the cells are furnished with fibres. On the dorsal side of the anther a few cells of the connective become lignified.

A difference in structure is seen below the place of dehiscence as shown in fig. 24. The epidermal cells, corresponding in position to the stomial groove, are radially elongated and slightly thickened. There is here no indication of stomial structure. Nor is the hypodermis so characteristically differentiated as a mechanical layer, for only some of the cells show fibrous thickenings, and the arrangement of these is

indifferent. In the hypodermal cells underlying the slight lateral depression fibres are generally though not consistently

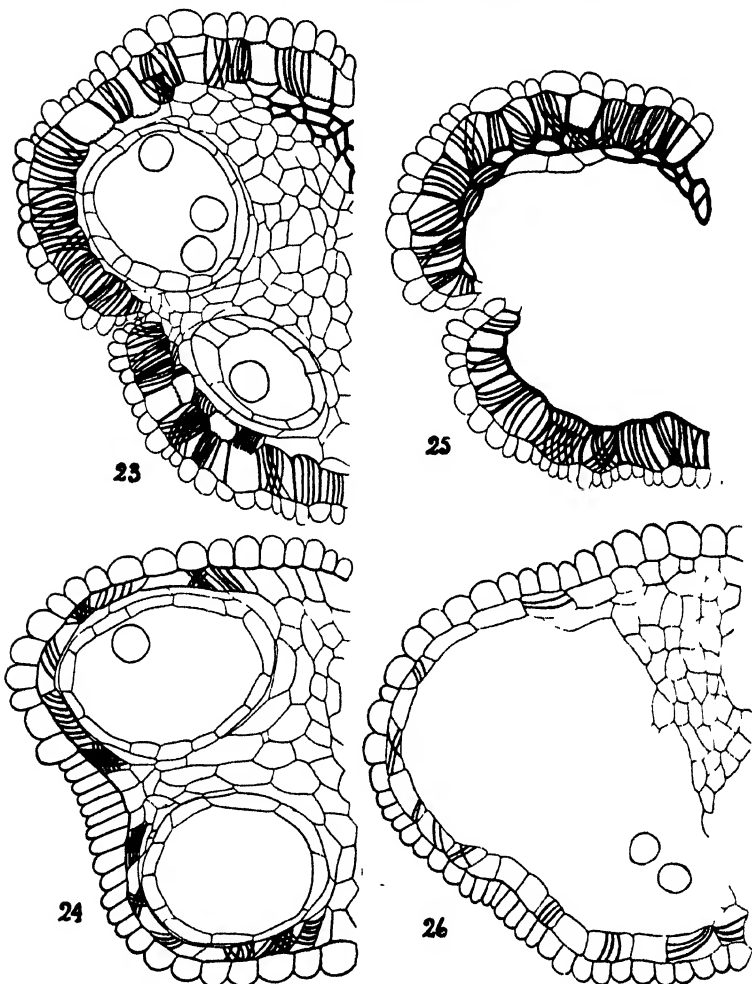


FIGS. 21 and 22.—*Ochna serrulata*. Fig. 21, side view of anther showing terminal slits (< 22); fig. 22, a series of transverse sections through young anther at levels indicated in fig. 21.

absent, again suggesting the loss of a functional longitudinal suture.

Dehiscence is apparently due to desiccation, bringing about contraction of the fibrous layer in the apical part of the anther, causing rupture of the thin-walled cells of the stomium (fig. 25). But in the lower part of the anther (fig. 26) this rupture is not effected. The mechanical layer, as already

described, is poorly developed and remains obsolete, and no stomium occurs. Thus, in *Ochna serrulata*, dehiscence is of



FIGS. 23-26.—*Ochna serrulata*. Fig. 23, transverse section through apex of anther lobe where dehiscence occurs showing stomium and well-developed endothecium; fig. 25, the same after dehiscence; fig. 24, transverse section through anther lobe below place of dehiscence, showing absence of stomium and obsolete fibrous layer; fig. 26, transverse section through lower part of mature anther. (All figs. $\times 166$.)

the false porose type, the restriction of the vertical slit to a subapical position being due to a localisation of the functional mechanism.

DISCUSSION.

The subdivision of porose dehiscence into two sharply defined types—true porose and false porose—as advocated by previous workers, cannot be strictly maintained. It is true that in *Ochna serrulata* dehiscence is of the false porose type, and there seems little doubt that we have here a derivative state, the opening by subapical slits having arisen from an original longitudinal fissure through failure of the mechanism in all but the distal part of the anther. The fibrous layer persists to the base, but in a functionally degenerate form, and the localised thickening of the epidermal cells along the sutures appears to be a strengthening of a previous line of weakness. The condition in *Cassia australis* is somewhat similar, although the end result has been attained along different lines. There is no typical fibrous endothecium, although occasionally fibrous thickenings develop in isolated cells, but the hypodermis, especially in the region of the pore, is so constructed as to function as a mechanical layer. The extension of distinct stomial grooves to the base of the anther is suggestive of an original longitudinal opening, but the remarkable plugging of the grooves and the development of a hypodermal clamp determine the localisation of the apical slits. In addition, *Cassia australis* shows a resorption tissue in the pore area, the disintegration of which is a preliminary step to actual anthesis.

Leclerc du Sablon, while recognising two types of porose dehiscence, subdivided the false porose forms into three groups, the first comprising those forms in which the fibrous layer extends the whole length of the anther, although it is functional only at the apex, as in *Ochna serrulata*; the second type where the fibrous layer is present only at the apex; and the third embracing such forms as have no fibrous layer, but dehiscence is still effected by a physical process located in the hypodermis. To the third group he refers *Cassia eremophila*, the species he investigated.

If porose dehiscence is a derivative state, arising from a shortening of a longitudinal slit, two possible lines of development may be considered. If the original condition was one of dehiscence by longitudinal slits controlled throughout by an efficient mechanical process located in a fibrous layer, then

a restriction of the mechanism to the apical part of the anther would result in such forms as constitute Leclerc du Sablon's first group, and the derived nature of the structure would still be evident. A further advance along this line, resulting in the elimination of the mechanical layer except at the apex, would give rise to his second group. On the other hand, if the original condition was one in which the mechanism of the fibrous layer was not highly evolved and effective, and according to Chatin such forms are not rare, then dehiscence restricted to the apical part of the anther might be accompanied by some further device to secure successful pore formation. This seems to be achieved by the resorption of tissue at a given point, and it is not impossible that certain true porose forms, for example in some of the Ericaceae and Melastomaceae, may represent the climax of such a line of development. *Cassia australis* would indicate an intermediate stage in such a transition.

In this connection the structure of the anther in *Galanthus* is of interest in that it provides an example of what appears to be an early stage in the transition from dehiscence by longitudinal slits to a porose type. For a full account reference may be made to the work of Troll (1928), but a short statement may here be made based on our own observations, which were made before Troll's paper came to our notice. Church (1908) refers to the tendency in the snowdrop to restrict the shedding of the pollen to the distal portion of the anther, thus constituting a sprinkling apparatus in the pendulous flower. Dehiscence is functionally if not morphologically porose. The anther is broad at the base, tapering towards the apex to form a short, sterile point. Transverse sections through this apical part show it to be roughly hemispherical in outline, having on the dorsal side a narrow band of sub-epidermal tissue composed of cells whose inner tangential and radial walls are conspicuously thickened, recalling, as Troll points out, the cells of a fern annulus. This band functions as the mechanical layer, but there is also the suggestion of resorption tissue in the region of the stomium. In the fertile part of the anther the wall is composed of epidermis of strongly papillose cells and hypodermis of tangentially elongated cells, thickened on the radial and inner walls. This thickened hypodermis is incomplete, however, for near the stomium the cells

are thin-walled. Towards the base of the anther the differential thickening of the hypodermal layer disappears. When dehiscence occurs the thin-walled tissue at the sterile apex breaks down, and the contraction of the hypodermal layers causes rupture of the stomium and separation of the valves. Below the apex the contraction is not enough to bring about an efficient longitudinal slit, and in the basal part of the anther, where the endothecium is rudimentary, the four pollen sacs remain distinct and no rupture occurs. It would appear that the abortion of a functional endothecium already apparent at the base has only to progress distally to complete the transition from functional to morphological porose dehiscence of the anther. The sterile apex with local disintegration of tissue is already present.

SUMMARY.

The structure and dehiscence of the anther in four species selected from different families is described.

In *Tibouchina semidecandra* the anther opens by a terminal pore through the dissolution of a previously prepared tissue. There is no mechanical layer present, and dehiscence conforms to the true porose type.

The structure in *Tetralthea pilosa* recalls that of some of the Vacciniaceae described in a previous paper. A sterile column surmounts the fertile portion of the anther, indicating sterilisation of originally fertile tissue. At the apex of this column a narrow slit is present which eventually opens to form a circular pore for the liberation of the pollen. Connection with the pollen sacs is established by the formation of a channel which passes through the sterile prolongation, which thus becomes a pollen-conveying tube.

In *Cassia australis* and in *Ochna serrulata* dehiscence is referable to the false porose type. In the former no fibrous layer develops although the hypodermis in the apex of the anther functions as such. The restriction of the slit to a sub-apical position is largely due to a hypodermal clamp, which prevents separation of the valves in the lower part of the anther. In *Ochna serrulata* a typical fibrous layer appears in the upper part of the anther where dehiscence is effected, but lower down it is more or less obsolete, and failure to

function is partly due also to a change in structure in the epidermal cells along the line of the original longitudinal suture.

The paper concludes with a short discussion in which it is suggested that porose dehiscence has been derived from longitudinal dehiscence through shortening of the longitudinal slit, and the view is held that this shortening and the final establishment of terminal or subapical pores has been reached in different ways.

REFERENCES.

- CHATIN (1870): De l'Anthère. Paris.
— (1874): Organogénie comparée de l'Androcée. *Comptes Rendus*, lxxviii, 1280.
CHODAT et BALICKA (1893): Remarques sur la structure des Tremandracées. *Bull. de l'Herbier Boissier*, i, 344.
CHURCH (1908): *Types of Floral Mechanism*. Oxford.
LECLERC DU SABLON (1885): Recherches sur la structure et la Déhiscence des Anthères. *Ann. Sc. Nat.*, ser. vii, 1, 97.
MATTHEWS and KNOX (1926): The Comparative Morphology of the Stamen in the Ericaceae. *Trans. Bot. Soc. Edin.*, xxix, 243.
NAMAKAWA (1919): Über des Öffnen der Antheren bei einigen Solanaceen. *Bot. Mag. Tokyo*, xxxiii, 62. Reference in *Bot. Abstracts*, iii, 358.
THOMPSON (1925): *Studies in Advancing Sterility*.—Part II. Publications of the Hartly Botanical Laboratories, No. 2.
TROLL (1928): Über Antherbau, Pollen und Pollination von *Galanthus*. *Flora N. F.*, xxiii, 321.
ZIEGLER (1925): Beiträge zur Kenntnis des Androeceums und der Samenentwicklung einiger Melastomaceen. *Bot. Archiv.*, ix, 398.

NOTES ON THE INTRODUCTION AND DISTRIBUTION OF THE
IVY-LEAVED TOAD-FLAX (*Linaria Cymbalaria* Mill.) IN
SCOTLAND. By HUGH BOYD WATT.

(Read 14th February 1929.)

The accepted belief has been that Dillenius in the year 1724 was the first recorder of this species as a British plant (see Trimen and Dyer's "Flora of Middlesex," 1869, p. 199, and other authorities). He considered that the Physic Garden at Chelsea was the place from whence this plant, a native of Italy and of South Europe, originated in England, or at all events about London. It has, however, recently been ascertained from John Goodyer's notes that its first introduction was into William Coys' garden at Stubbers, North Ockington, Essex, in the early seventeenth century, and that it was planted in Goodyer's garden, Droxford, Hants, in 1618.¹ From thence it became dispersed over the British Isles. It is a prolific flowerer and well deserves the name of Mother of Thousands, by which it is known in the west of England. Other vernacular names are Roving Jenny and Roving Sailor.

In Scotland, as might be expected, the plant is not mentioned in the works of the pioneers of Scottish botany—John Reid, "The Scots Gard'ner" (1683); Robert Sibbald, "Scotia Illustrata" (1684); and John Lightfoot, "Flora Scotica" (1777). The Edinburgh Botanic Garden was founded in 1670, and by 1683 is said to have contained three thousand species of plants, but this *Linaria* is not named. Mr. J. R. Matthews, Royal Botanic Garden, Edinburgh, tells me that he has no knowledge of the plant's introduction to that Garden, but since the Garden has occupied its present site for just over a century its cultivation would not date so very far back. He also says that it is just possible that the plant was cultivated in one or other of the other gardens before removal to Inverleith Row.

The probability is that it was brought into Scotland as a garden plant during the period when planting and gardening

¹ R. T. Gunther, "Early English Botanists" (1922), p. 164. Mr. Gunther adds that the first mention of English *Cymbalaria* is in Coys' Garden List of 1617, p. 317.

came into vogue about the beginning of the eighteenth century, but the first Scottish record is in Thomas Hopkirk's "Flora Glottiana" (1813) at Bothwell Castle on the Clyde, where it continues at the present time. I have to thank my old friend, the late John Paterson, for telling me of this. Sir W. J. Hooker, in "Flora Scotica" (1821), considered it very rare, and mentions the Bothwell Castle station, as does Henny's "Clydesdale Flora" (1878), and the last named has the further note, namely, "garden walls in various places." Patrick's "Flora of Lanarkshire" (1831) contains the species. The "Annals of the Andersonian Naturalists' Society," Glasgow (1893), note its occurrence at Chatelherault (Cadzow), Lochwinnoch, and Balloch Castle, and the British Association Handbook on the Clyde Area (1901, p. 123) records the species in four divisions. My own first acquaintance with this attractive species was on the occasion of an Andersonian Naturalists' Society excursion to Chatelherault about forty years ago, when its abundant festoons of delicate pale purple flowers were a delight to the eyes.

The species is well distributed in the Clyde area, and I am indebted to observers in the above-named Society for the following information.

At Barncluith (Hamilton) it has spread so much over the old gardens that it recently had to be cleaned off the walls as a troublesome weed. In Upper Clydesdale it occurs so far up as near Elvanfoot (Dr. Donald Patton). In Renfrewshire it is recorded as rare, but on the walls of the old Collegiate Church at Lochwinnoch it used to be plentiful, and probably is so still. In Dumbartonshire it is found on the kitchen walls at Balloch Castle, and at Rhu it is remarkably abundant on walls. At Garelochhead and at Ardmay, below Arrochar, it has been long known to Mr. John R. Lee. Mrs. P. Ewing reports that she found it at Kilmun, Argyllshire, first about the year 1884, since when it has spread and is now abundant there. Dr. Patton reports its abundance in the Island of Bute. In Ayrshire the species is recorded as an alien. Farther south it is described as an outcast or escape in Dumfriesshire and Kirkcudbrightshire, and localities mentioned are Kirkcudbright, 1882; Dumfries, 1890; and Wigtown, 1893. In Peeblesshire it is noted as common on walls, but originally introduced. In the eastern Border counties, *Linaria* is recorded previous to

1853 as "established in so many gardens, on walls, etc., that its eradication would be difficult. It is a favourite window flower with cottagers." North Berwick is another locality named farther north.

In the Forth area there are early records in the works of James Woodforde and Greville, both dated 1824, and the stations named are the debris of Salisbury Craigs, wall near Newhaven, and new road to Portobello, Trinity Mains. Miss I. Martin (1927) says that the species is frequent, and the localities show that it occurs on or about all the old castles and similar buildings of the district.

In the vicinity of Larbert, Stirlingshire, it occurs on a wall round a wood, well away from gardens. Instances of this character, some distance away from possible centres of cultivation, are exceptional.

In Perthshire it is recorded as naturalised on some old walls, and in Forfarshire there was only one record in 1848. The late Dr. William G. Smith of Edinburgh told me that at a later date he knew this station and that the plant now occurs in other places in Forfarshire, but not in so many as in the Lothians. Stations named by another observer are at a small village near Montrose and on a garden wall at Bervie in Kincardine.

In Aberdeenshire it is recorded, previous to 1853, for the Den of Rubislaw and on old walls, but always the outcast of a garden, and at a later date Ferryhill and elsewhere around Aberdeen are named. The "Trail Memorial Volume" (1923) gives five stations in Aberdeen, and the species occurs in only one, doubtfully two, parishes adjacent to Aberdeen.

In Banffshire the parishes of Fordyce, Banff, Gamrie, Alvah, King Edward, Rothiemay, and Aberlour are named. The parish of Fyvie is named by the late Professor Trail.

There is an early record from Elginshire, namely, on the wall at Gordon Castle, 1832: rare and certainly introduced.

On the north-west coast the only report I have is that the species occurs on an old castle in West Ross-shire, and in various places in the west, Loch Duich and elsewhere.

Farther south it occurs on walls near Oban, Argyllshire.

The list annexed names the authors from whose works information has been collected, but this does not make any claim to be exhaustive.

I have also gratefully to acknowledge assistance kindly given by the late Dr. William G. Smith of Edinburgh ; Mr. J. R. Matthews of the Royal Botanic Garden, Edinburgh ; and Mr. John R. Lee of Glasgow, without whose help these notes would have been much less complete.

LIST OF AUTHORITIES.

- (1) Andersonian Naturalists' Society "Annals," Glasgow, 1893.
- (2) BUCHAN'S "History of Peeblesshire," 1925, vol. i, chap. x—F. R. S. Balfour and A. B. Jackson.
- (3) 'RAIB, W. G. : "Flora of Banffshire." (1912.)
- (4) ELLIOT, G. F. SCOTT : "Flora of Dumfriesshire." (1896.)
- (5) "Fauna, Flora and Geology of the Clyde Area." British Association Meeting, Glasgow. (1901.)
- (6) FERRIER, GEORGE : "North Berwick and its Vicinity." (1875.)
- (7) GARDINER, W. : "Flora of Forfarshire." (1848.)
- (8) GREVILLE : "Flora Edinensis." 1824.
- (9) GORDON, REV. DR. GEORGE : "Flora of Moray." (1839.)
- (10) HENNEDY, ROGER : "Clydesdale Flora." (1878.)
- (11) HOOKER, SIR W. J. : "Flora Scotica." (1821.)
- (12) HOPKIRK, THOMAS : "Flora Glottiana." (1813.)
- (13) JOHNSTON, G. : "Botany of the Eastern Borders." (1853.)
- (14) MACGILLIVRAY, P. H. : "Flora of Aberdeen." (1853.)
- (15) MARTIN, I. : "The Field-Club Flora of the Lothians." (1927.)
- (16) MCANDREW, JAMES : "A List of the Flowering Plants of Dumfriesshire and Kirkcudbrightshire." (1882.)
- (17) Paisley Naturalists' Society, "Transactions," vol. ii, 1915. D. Ferguson.
- (18) PATRICK : "Flora of Lanarkshire." (1831.)
- (19) SMITH, JOHN : "Botany of Ayrshire." (1896.)
- (20) TRAIL, J. W. H. : "List of Casuals and Introduced Plants in N.E. Scotland," Scot. Nat., 84. (1883.)
- (21) — "Flora of Buchan." (1902.)
- (22) WHITE, F. BUCHANAN : "Flora of Perthshire." (1898.)
- (23) WOODFORDE, JAMES : "A Catalogue of the Indigenous Phenogamic Plants growing in the Neighbourhood of Edinburgh." (1824.)

CORK FORMATION IN RHODODENDRON.

By C. MARION BARON.

(Read 16th May 1929.)

The formation of cork in the stem of most species of *Rhododendron* is of two kinds; firstly of pericyclic and later of cortical origin. The pericyclic cork is formed early in the green stem, usually appearing first behind the gaps between the masses of pericyclic fibres. It quickly forms a cylinder, 2-3 cells wide, of suberised rectangular cells, completely enclosing the stele, often before the pericyclic fibres are fully developed. In a very few species, such as *R. primulinum*, *R. obtusum*, and *R. longistylum*, this cork layer apparently acts as an effective barrier between stele and cortex, the latter being cut off from supply and dying off gradually down the stem. This is evident on the external surface of the stem sometimes as a gradual transition, sometimes as a definite junction of green and brown colour. The species which show only this pericyclic cork appear to be those which possess a very narrow cortex and a particularly early development of cork in the young stem. In *R. primulinum*, for example, the cork layer when fully developed (3-4 cells wide) may measure as much as half the width of the entire cortex, while in large stems, like that of *R. fulgens*, the width of the cork layer is about 1/40th or less of that of the cortex.

This effect, however, produced on the cortex by the pericyclic cork only, seems to be exceptional. The majority of stems show a sharp junction of green living tissue and brown withered bark, usually in the basal part of the last year's growth. This junction runs irregularly round the stem, often extending for several inches up on one side. Below the junction, patches of living green tissue, varying in size, can often be found enclosed in the dead bark. These occur sporadically, sometimes but not necessarily connected with old leaf or bud traces. The bases of the older leaves are often surrounded by similar patches of green tissue where the rest of the stem is brown; these turn brown some time after the leaf has fallen.

Transverse sections taken across the junction from above

downwards show an unusual development of cortical cork. Some time after the pericyclic cork layer is complete, the cells between the pericyclic fibres on one side of the stem, and then those immediately outside them, become lightly suberised (fig. 1, i, and fig. 2). These cells proceed to divide tangentially,

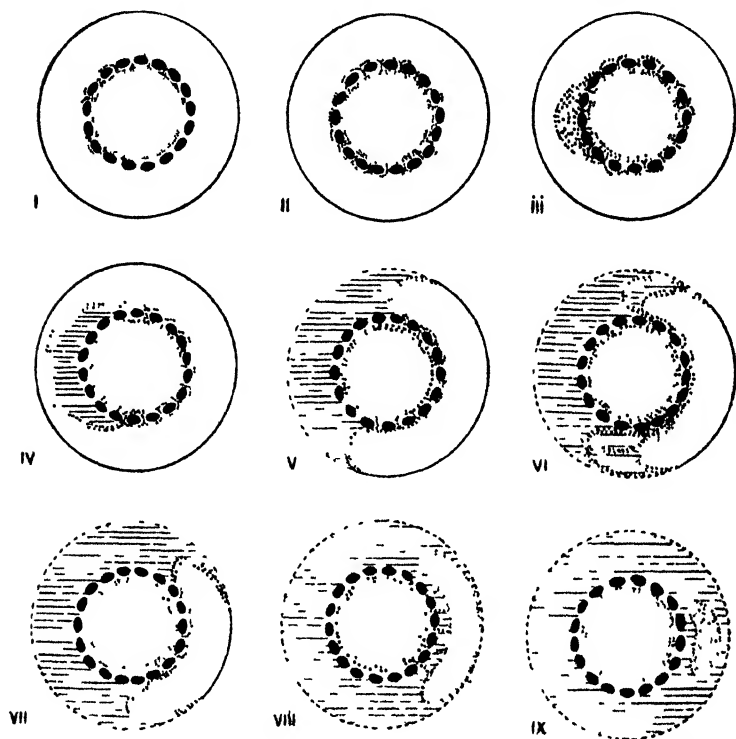


FIG. 1. -Diagram to show stages of cortical cork development, passing down the stem. Pericyclic fibre masses indicated in black, dead cortex in horizontal lines, cork in dotted lines.

and the sclerenchyma masses thus become enclosed on all sides by a layer of cork, 2-3 cells deep (fig. 1, ii). The cortex immediately outside this becomes closer in texture and shows a great accumulation of starch. Passing farther down, almost into the brown portion of the stem, this meristematic activity affects the cortex farther and farther out, until eventually two arcs of cork tissue are formed (fig. 1, iii, iv, and v). These take a curved, oblique course through the cortex from the inner cork cylinder to the epidermis, cutting off between them a mass of

cortex which quickly dies. New phellogen layers arise in the same way in the still living cortex (fig. 1, vi), and each is

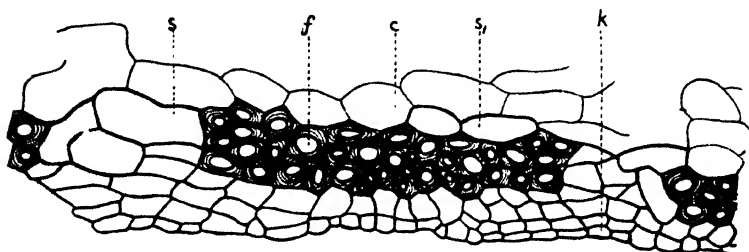


FIG. 2.—Camera lucida drawing, showing suberisation of the cells between and outside the pericyclic fibres.

c=living cortical cells ; f=pericyclic fibres ; s=suberised pericyclic cells ; s₁=suberised cortical cells ; k=pericyclic cork cylinder.

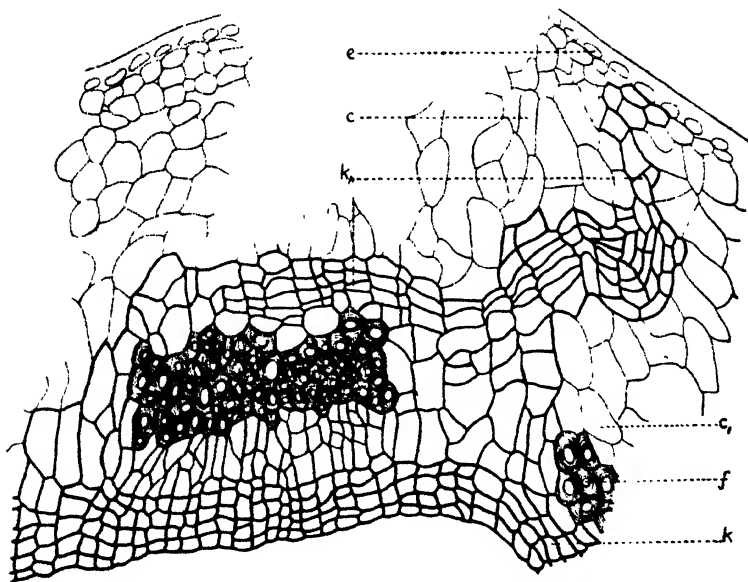


FIG. 3.—An advanced stage in cortical cork formation.

c=living cortex ; c₁=dead cortex ; k=pericyclic cork ; k₁=cortical cork ; f=pericyclic fibres ; e=epidermis.

accompanied by a heaping up of starch in the adjacent cortical cells. Fresh masses of cortex are thus cut off, until the two phellogen layers meet and coalesce on the opposite side of the stem from which they arose. At this point the whole of the external surface of the stem appears brown, a small patch of

central cortex being the only living tissue left outside the stele (fig. 1, viii). This becomes smaller, and the final stage of meristematic activity is seen in the small patch of suberised cortical cells at the base of the junction. The whole of the cortex below this level is completely dead and devoid of contents.

This method of cork formation in *Rhododendron* was investigated on account of some work published by Priestley (1) in which he correlated the pericyclic origin of the phellogen in the stem with a functional endodermal barrier, the latter causing accumulation of sap inside the stele and thereby determining the position of any future meristematic activity. In a later paper (2) Priestley expresses the opinion that the pericyclic fibres function in the same way. In *Rhododendron*, however, the fibres very rarely form a continuous band, and further, the pericyclic cork layer is often completed some time before the fibrous layer. Of greater interest in this connection is the development of several phellogen layers in a cortex which is still green and living for an indefinite time after the completion of the pericyclic cork cylinder. To account for this, two alternatives may be suggested; either the cork cells formed by the pericyclic phellogen are not completely impermeable, or else the extent of conduction in the cortical cells is greater than has hitherto been supposed.

My thanks are due to Professor Wright Smith, of the Royal Botanic Garden, for providing facilities for this investigation, and to Dr. Graham for invaluable suggestions throughout the work.

REFERENCES.

- (1) PRIESTLEY, J. H., and WOFFENDEN, LETTICE M. (1922): *New Phytologist*, xxi, 252-268.
- (2) — (1926): *Proc. Leeds Phil. Soc.*, 1, pt. iii, 123-135.

VACCINIUM INTERMEDIUM RUTHE ON THE SOUTH PENNINE
MOORS AND ON CANNOCK CHASE. By W. BALFOUR
GOURLAY, M.A. (With Pl. XI.)

(Read 27th June 1929.)

Vaccinium intermedium of Ruthe—a natural hybrid between the bilberry, blueberry, or whortleberry (*V. myrtillus* Linn.), and the cowberry (*V. vitis-idaea* Linn.)—has been reported from a few places only in Europe and Great Britain. On Cannock Chase in Staffordshire, however, it is by no means rare. I was fortunate in seeing a good deal of it in that area when military duties kept me stationed there during the greater part of the year 1919. Before leaving Cannock Chase I knew at least thirty separate sites of the plant (1). Considering its comparative abundance on Cannock Chase, I often wondered whether the hybrid could really be as rare elsewhere as it was reputed to be. However, since 1919 I have wandered in uplands covered with bilberry and cowberry in Scotland, Switzerland, Norway, and North Russia, but in none of these countries have I seen a trace of the hybrid. It would be interesting to know why this plant should be comparatively common on Cannock Chase and extremely rare elsewhere.

In June 1928 I paid a visit to the garden of an acquaintance who lives at Whirlow, a suburb of Sheffield. My host had in his fine rock-garden a border of cowberry, but complained that bilberry was always cropping up among it and replacing the cowberry if not eradicated. "Here," I remarked, "we might find the hybrid, but are not in the least likely to do so." The words were scarcely out of my mouth when I noticed a patch of it, and then another and another—four or five in all! These patches of *Vaccinium intermedium* were so distributed as to make it almost certain that the hybrid plant, like the bilberry, had been accidentally introduced along with the cowberry from its wild moorland home.

I had no opportunity of going farther into the matter at the time, as I was paying but a hurried passing visit, but returned to the garden and its problem a month later. My

host then informed me that, some twenty or twenty-five years previously, a neighbouring farmer had supplied him with the cowberry plants; and that, moreover, this man was still alive and doubtless able to point out the spot where he had obtained them. This proved to be so. The farmer had obtained the cowberry plants near a disused quarry, whose position he described so accurately that we found it without difficulty. Near one end of the quarry was growing a patch of *Vaccinium intermedium* of some fifty or more square yards in extent. The site is about six miles south-west of Sheffield, on the Hallam Moors, from a mile to a mile and a half south of Redmines Reservoirs and just south of the Yorkshire-Derbyshire county boundary—and consequently in the latter county. A few hundred yards away, on the track leading (via Ringinglow Inn) to Sheffield, was another small patch of the hybrid *Vaccinium*. The track at this point coincided with the county boundary, and the plant, growing as it did on the north side of the track, was consequently in Yorkshire. (It is more than probable that some twenty or more years ago the farmer, with his cart full of cowberry plants, had discarded by the wayside what he considered an atypical sample, which, however, grew and flourished where thrown aside.) On the neighbouring moorlands bilberry and cowberry grew together abundantly, but none of the hybrid could be found.

In March 1929 I happened to be walking over the Midhope Moors, some ten miles or so N.N.W. of the aforementioned spot. Though bilberry and cowberry were everywhere abundant, I had to walk several miles before detecting a small patch of the hybrid growing under a stone wall some one and a half to two miles south or south-west of the village of Langsett (South Yorkshire).

It was curious to note (in 1919) that the Staffordshire plants of *Vaccinium intermedium* almost invariably grew where some disturbance of the ground had occurred, as was also the case in the Hallam Moor patch found growing about an old quarry.

Vaccinium intermedium is easily seen in winter or early spring, as it retains most of the leaves of the previous season, while the stiff, angular bilberry stems are then leafless. The leaves of the hybrid plant are thinner, less glossy, and more pointed than those of cowberry, from which it also differs in having the leaf margin serrated and not revolute. The terete

stems of the two plants are similar, though the upper twigs of *V. intermedium* are often slightly angular.

The Hallam and Midhope Moors in the South Pennines are on a millstone grit formation, while the Staffordshire sites of *Vaccinium intermedium*--Cannock Chase and the more northerly Whitmore district—are on pebble beds and bunter sandstone.

Johann Friedrich Ruthe discovered *Vaccinium intermedium* not far from Berlin in 1826, and described and figured the plant in his "Flora of Brandenburg" (2). In 1870 Mr. Ball, F.R.C.S., noted a strange *Vaccinium* growing in Maer Woods, near Whitmore in north-west Staffordshire. He sent specimens of it to Mr. Robert Garner, who, believing this plant to be a hybrid between the bilberry and cowberry, showed it as such to the Linnean Society in March 1872. But, unfortunately, the Society was not convinced by Mr. Garner's arguments, and recorded their opinion that the plant was "a luxuriant state of *V. Vitis-idaea*, due to situation, rather than a hybrid" (3). Professor T. G. Bonney found *Vaccinium intermedium* on Cannock Chase in 1886, Mr. N. E. Brown recording this discovery (4). Mr. Garner then submitted his plants from Maer Woods to Mr. Brown, who identified them as undoubted examples of *Vaccinium intermedium* Ruthe (5).

Charles Darwin often stayed with his relatives, the Josiah Wedgwoods, at Maer, and it was perhaps on one of these occasions that Mr. Garner showed him a specimen of the hybrid *Vaccinium*. Darwin, considering the shrivelled pollen grains, which Mr. Ball had also noted, stated that the plant would probably prove to be sterile (6).

The Staffordshire plants that I observed in 1919 all showed sterility in varying degrees. To quote from my notes, made at the time: "I have found large patches of the hybrid without sign of flowers or of the plum-violet coloured fruits; and from a comparatively small patch (measuring 3 by 7 yards) I have picked over 200 ripe berries without exhausting the supply. One hundred of these berries, however, only yielded 209 apparently well-developed seeds, against more than 300 seeds from 100 berries collected at random from a variety of patches. (Bilberry and cowberry fruits showed a much higher percentage of good seed.) The small hybrid patch, yielding much fruit but little seed, was a mere isolated

remnant round which a moorland fire had swept, and was an almost pure growth of the hybrid, containing but a trace of cowberry at one spot. Nine yards away a few small plants of bilberry had survived" (1).

Seeds from the isolated hybrid patch were sent to the Edinburgh Botanic Garden on 25th August 1919 and sown in a pan (see Plate XI, A). Seeds collected at random from various patches were also sent there and sown in a separate pan (see Plate XI, B). The results were strikingly different. From the isolated patch sprung a few very feeble hybrid seedlings (Aa), and one thriving plant which was indistinguishable from cowberry (Ab). The seeds collected at random produced many luxuriant seedlings showing considerable variety in habit and in shape of leaf, etc.: yet all were undoubtedly examples of *V. intermedium*, as could be seen by the terete stems associated with serrated leaf margins. (After this I went abroad and lost trace of the further progress of the seedlings.)

During a visit to Washington, D.C. (U.S.A.), in the autumn of 1922 I met Mr. Frederick V. Coville, a Government botanist of the Agricultural Department. Mr. Coville had been making experiments in the cultivation of "blueberries" (*Vaccinium corymbosum* Linn.), and found that this species is sterile to its own pollen, i.e. to pollen from flowers of the same individual plant (7). Mr. Coville told me about an allied plant in North America, the "box huckleberry" (*Gaylussacia brachycera* Torr. et Grey), which shows a striking resemblance to *Vaccinium intermedium* in its mode of occurrence. In 1919 only two plants of the box huckleberry were known to exist wild in North America. In Pennsylvania there is an enormous plant of it, with a spreading but sharply defined margin, which occupies an area of about eight acres, and is estimated to be over one thousand years old. Its spread, by creeping rootstocks, is held up on one side by a tiny stream which it cannot cross. It produces flowers and fruit in abundance, but no seedlings can be found. In 1918 Mr. Coville collected and planted under good conditions 1600 seeds, but obtained only three feeble seedlings (8). A similar plant of box huckleberry is known in Philadelphia, but occupies only twenty feet square. (The largest plants of *Vaccinium intermedium* which I found on Cannock Chase occupied about a third of an acre.) The vegetative vigour of the plant, combined with its sexual sterility, suggested

to me that *Gaylussacia brachycera* might be an hybrid; but Mr. Coville thought not, as no likely parent forms occur in its neighbourhood. He considered it probable that the two plants were originally chance seedlings from seeds carried by birds beyond the original main range of the species, and that the latter might all have been wiped out of existence at a later date by some destructive insect or fungus.

Mr. Coville's experiments with *Vaccinium corymbosum* and *Gaylussacia brachycera* suggest a possible explanation of why *Vaccinium intermedium* is everywhere extremely rare except in one or two such favoured places as Cannock Chase and Maer Heath, where it is relatively common.

Original hybrids probably occur infrequently and far apart. If sterile to their own pollen they could then increase only in size, but not in numbers. Cross pollination of the hybrid with bilberry or cowberry may perhaps reproduce, if anything, only bilberry or cowberry. But if, say, on Cannock Chase or Maer Heath separate acts of cross pollination of cowberry and bilberry had happened to occur near together, the resulting hybrids might then be able to reproduce their kind, and perhaps tend to increase. It is even possible that some of the hybrid patches on the Chase may consist of more than one plant, and so (unaided by pollen from elsewhere) may produce fertile fruit. Seeds of such fruit would be carried by birds to various parts of the Chase. And, moreover, the resulting vigorous hybrid seedlings might gain an advantage over their young bilberry or cowberry competitors were they to occupy newly broken ground where they could establish themselves and assert their superior vigour. (Cannock Chase being as popular for military manoeuvres as for the holiday picnickers, is peculiarly liable to such local disturbance.) And so we could account (1) for the usual rarity of *Vaccinium intermedium* except in favoured spots such as Cannock Chase and Maer Heath, and (2) for its usual occurrence on artificially disturbed or otherwise newly broken ground.

REFERENCES.

- (1) GOURLAY, W. B.: Notes from Cannock Chase on *Vaccinium intermedium* Ruthe. Trans. Bot. Soc. Edin., xxvii, pt. 4 (1919), 327.
- (2) RUTHE, J. F.: Flora der Mark Brandenburg und der Niederlausitz, 377, pl. 1.

- (3) Journ. of Bot., x (1872), 122.
- (4) BROWN, N. E.: *Vaccinium intermedium* Ruthe, a new British Plant. Jour. Linn. Soc., xxiv (1887), 125.
- (5) — Postscript. *Ibid.*, 128.
- (6) GARNER, R.: A Curious British Plant. Hardwicke's Science Gossip (1872), 248.
- (7) COVILLE, F. V.: Directions for Blueberry Culture. U.S. Dept. Agr., Bull. 974 (1921), pl. 22.
- (8) — The Threatened Extinction of the Box Huckleberry, *Gaylussacia brachycera*. Science, n.s., 1 (1919), 30.



Seedling plants of *Vaccinium vitis-idaea* L. in the Royal Botanic Garden, Edinburgh.

[Handwritten signature]

PRELIMINARY REPORT ON A VARIETY OF RED CURRANT
RESISTANT TO WEYMOUTH PINE RUST. By GLENN
GARDNER HAHN, B.Sc., M.Sc., Ph.D. (With Pls. XII-
XIII.)

(Read 27th June 1929.)

Wild-growing *Ribes* in Europe may be regarded as negligible in their influence upon the distribution of *Cronartium ribicola* Fischer, which causes the destructive disease of the Weymouth (*Pinus strobus* L.) and other five-needled pines. This heteroecious rust, which alternates in its life-cycle between pines and species of the Grossulariaceae, is comparatively new to North America, where it was introduced upon diseased nursery stock from Europe. In Britain, Professor Somerville stated in 1909 that the future for Weymouth pine was hopeless because of the rust. Cultivated *Ribes*, including gooseberries, red and white currants and the black currant (*R. nigrum* L.), are generally grown on this side of the Atlantic; the last-named species is so prevalent that, according to Spaulding (7), practically all the damage from *C. ribicola* seen by him in the British Isles and on the Continent may be attributed to this alternate host.

In contrast with the abundance of cultivated *Ribes* and the negligible number of wild species in Europe, the wild *Ribes* in North America are commonly the controlling factor in the spread of the rust. At the same time, the United States in its control programme of the white-pine blister rust (as the disease is known there), has been forced to reckon with the no less important but considerably smaller number of cultivated *Ribes*. In certain areas these as well as the wild species have been summarily eradicated, particularly the extremely susceptible *R. nigrum*, the most serious malefactor in the spread of the disease which is now established in the very valuable eastern and western white-pine forests of the United States (3).

Extensive investigation in the United States has been directed toward the determination of the estimates of the susceptibility to white-pine blister rust, of the various wild

and cultivated species and varieties of *Ribes* growing there in association with five-needled pines. It has been the experience of workers in this particular field that, generally speaking, *Ribes* species are decidedly susceptible to *C. ribicola*. Only a few species have been discovered which have remained immune in the tests of artificial inoculation. It has been found that the varieties of a cultivated species run fairly true to the species as a whole. What variation in susceptibility occurs depends upon their mixed parentage. Amongst the large number of varieties of the cultivated red and white currants tested, Spaulding (6) reports the following as resistant but not entirely immune: Eyatt Nova, Franco-German, Holland, Rivers Late Red, and Simcoe King. The author found only three varieties—Holland, Franco-German, and Victoria—to be immune amongst a large number of varieties tested.¹ These later tests, which were limited, must necessarily be repeated under rigorously controlled conditions, providing at the same time the most favourable stages of leaf development for the attack of the fungus, before a definite statement can be made concerning the type of infection. This applies particularly to the variety Victoria of the *R. rubrum* and hybrids group, which is regarded by Thayer (8) as probably identical with the well-known English variety, Ruby Castle, which both Spaulding and the author found to be susceptible.

Authorities on the origin of the red and white currants are in agreement, as a result of their investigations, that these horticultural varieties are of mixed and badly confused parentage (1, 2, 8). The general conclusion seems to be that certain varieties sprang from each of the three species, *R. sativum* (Rchb.) Syme (*R. vulgare* Lam.), *R. rubrum* L., and *R. petraeum* Wulf. It is here interesting to note that among the resistant varieties discovered by Spaulding and by the author, the following varieties belong to the *R. petraeum* and hybrids group—Holland, Franco-German (regarded as synonymous with Holland by Thayer), and Rivers Late Red. While Spaulding (6) and the author in this paper report *R. petraeum* as susceptible to *C. ribicola*, resistance to the rust would

¹ Hahn, G. G.: A Physiological Method of distinguishing *Cronartium ribicola* and *Cronartium occidentale* in the Uredinal Stage [MS., to appear in the Journ. Agr. Research].

appear to be a dominant character amongst certain of the cultivated hybrids of the *Petraeum* group.

RESISTANCE OF THE NORWEGIAN RED DUTCH VARIETY.

In 1927 the author, while studying the Douglas fir canker and European larch canker diseases in Norway, visited the Agricultural College at Ås, in company with Mr. Ivar Jørstad, the Government mycologist for Norway. Mr. Jørstad called attention to a variety of red currant regarded by him as being resistant to white-pine blister rust. The resistance shown by the variety was very evident. Conditions for rust infection were very favourable during the year 1927 in Norway, and rusts were everywhere abundant. The writer observed, however, that the plants of this Red Dutch variety were apparently quite free from infection, whilst leaves of plants of the variety White Dutch, in the nursery row immediately adjoining, were moderately to heavily infected.

Inasmuch as the author had previously tested the Red Dutch variety in the United States and found it to be susceptible to white-pine blister rust, he became especially concerned in ascertaining the identity of this resistant Red Dutch variety from Norway. It is here of interest to note that Thayer (8) in his treatise on the red and white currants with regard to their history, varieties, and classification, makes the following statement concerning the Red Dutch variety : —

“ It is probable that this variety shares with the White Dutch the honour of being the oldest currant known, always excepting, of course, the parent stock or ‘Common Red.’ The name Red Dutch first appears in print in 1670 or 1690. It is not to be supposed that the Red Dutch as grown to-day is the same as the Red Dutch of two centuries ago. In fact, the Red Dutch as grown in America and the Red Dutch (Hollandische Rote and Rouge de Holland) of continental Europe belong to different species, while we have received plants from England under the name Red Dutch belonging to still a third species. Mr. E. A. Bunyard’s description of the Red Dutch of England seems to tally with the variety as grown here. He holds the Red Dutch of the continent to be the same as the Rivers Late Red, Prince Albert, or Verrières Rouge. On the other hand, Mr. A. F. Barron, in reporting on the trial plots at Chiswick, England, gives Fertile d’Angleterre, Fertile de Palnau, Fertile de Bertin, La Hative, Hative de

Bertin, Bertin No. 9, Belle de St. Gilles, Chenouveau Grosse Rouge de Boulogne, Queen Victoria, and Red Grape as synonyms of Red Dutch, and describes the plant as follows: 'The plant is of a dwarf and somewhat slender habit of growth, never attaining a large size. The leaves are broad and flat, deep green, having a sort of metallic glaucous hue, which renders it in appearance quite distinct. The synonyms here given are all referable to this one variety, which is the one generally grown and known in this country as the Red Dutch.' This tallies with the plant received from England under this name.

"In America we find the Red Dutch catalogued as far back as 1823, although it was probably grown long before that date. In the Magazine of Horticulture for 1842 is a good, though incomplete, description: 'Clusters long, berries large; growth of the plant strong and upright, exceedingly productive, and one of the very best sorts.' In 1854 John Saul of Washington, writing for the 'Horticulturist,' described the Red Dutch as 'a free grower, good bearer, a fair-sized bunch, with large, high-colored, rich berries.' He also describes the Long Bunched Red Dutch as 'a fine, long-bunched, large-berried variety of the above. It is later and rather more acid.' The Red Dutch plants received from different American nurserymen all seem to agree and might easily come under this last description."

The synonymy of the red and white currants in general is so mixed that names mean very little and are unreliable. It therefore became highly probable that the Red Dutch observed in Norway was a plant of quite different origin from the Red Dutch grown in the United States. Further investigation has proved this to be the case. In a letter received from Mr. Jørstad on this score the following information concerning the Norwegian variety has been obtained:

"... I can inform you ... concerning the synonymy of the red currant strains in question. I have conferred with Mr. P. Stedje, leader of the Pomological Experiment Station at Hermansverk in Sogn. He is our best specialist in this matter and has ... quite a few American red currant strains in culture (these he obtained from Paul Thayer in Ohio).

"Mr. Stedje tells me that there is a great confusion concerning the names of one and the same strain. The Norwegian 'Rød hollandsk druerips' (i.e., Red Dutch Grape Currant), which is the one resistant to *C. ribicola*, is *not* identical with the Danish 'Rød hollandsk druerips,' but with their 'Rød spansk' (i.e., Red Spanish). Our 'Rød hollandsk druerips' is, further, *not* identical with the American 'Red

Dutch,' neither with Long Bunch Holland nor Victoria, but it is very similar to Prince Albert and to Rivers Late Red (the two latter are possibly identical). Our 'White Dutch,' which is susceptible to the rust, is, according to Mr. Stedje, not closely related to our 'Red Dutch,' and the same is the case with the American 'Red Dutch.' Although the two latter possess the same name they are entirely different."

It would therefore appear that the Norwegian Red Dutch currant, according to the present information at hand, is quite distinct from the Red Dutch variety [*R. sativum* (*R. vulgare*) hybrids group], and belongs within the group *R. petraeum* and hybrids, a group in which resistance to white-pine blister rust amongst certain varieties has already been reported.

It is here interesting to note that Tubeuf (9, p. 27) has reported a Red Dutch currant variety ("rote holländische Johannisbeere") immune to white-pine blister rust in Germany. In the above-mentioned paper he does not describe infection experiments, but he has stated, in a recent letter to the present writer, that he demonstrated the immunity of this variety many years ago by means of inoculations, and has, since that time, repeatedly verified his original conclusions. The actual identity of his Red Dutch variety, however, is not revealed in the paper, but he refers to a forthcoming report on immune currants and gooseberries which will include all hitherto unpublished details of his extensive series of infection experiments.

INOCULATION EXPERIMENTS.

Cuttings of Norwegian Red Dutch currant were obtained by the author during the autumn of 1928 from the Agricultural College, Ås, and from the Pomological Experiment Station at Hermansverk in Sogn, Norway, for artificial inoculation investigation at the Royal Botanic Garden, Edinburgh. Cuttings of the American Red Dutch variety which had come originally from Mr. Thayer, United States of America, were also obtained from the last-named Norwegian Station. In propagating plants of the latter variety it was the writer's purpose to utilise these as check plants in the experiments in order to demonstrate the viability of the spore inoculum used. At the same time it was the desire of the writer to repeat his inoculation results which previously had shown the American

Red Dutch to be susceptible to rust in the United States. In the present instance, however, British strains of *C. ribicola* were being used. Plants of the very susceptible golden currant *R. aureum* Pursh, and black currant (*R. nigrum* var. ?) were also included as check plants in the experiments. The inoculum was obtained from freshly collected specimens of diseased *Pinus Strobus* and *P. monticola* D. Don from Peeblesshire, Scotland.

The methods of inoculation used were identical with those described in a previous publication (4), except in this instance a bell-jar was used instead of the "iceless refrigerator." The first two inoculation sets in April were performed in a heated greenhouse where the temperature rose to 75° F. After removal from the moist chamber the plants were taken to an unheated greenhouse where the temperature fell frequently to 48° F. during April and the early part of May. Subsequent inoculation test sets were performed in the unheated greenhouse.

A total of ten comparative inoculation sets were made intermittently during the period 22nd April 1929 to 12th June 1929. Particular care was taken to utilise plants at the time when the leaf condition was optimum for rust infection. All of the plants reported in these experiments were not only healthy and vigorous but also unaffected by mildew or other fungi which might interfere with the parasitic attack of the *Cronartium*.

Among the susceptible plants, infection spots were observed to form within nine days and extruded urediniospores within twelve days. Necrotic flecks formed in the leaf tissue of the resistant Norwegian Red Dutch currant within nine days. The results obtained in inoculating plants of the Red Dutch variety from Norway, and the variety and species used as check plants, are presented in the table opposite.

INOCULATION OF *ribes petraeum*.

It has already been intimated in this paper that varieties of the *R. petraeum* and hybrids group have shown resistance to rust in previous experiments. Spaulding (6) reported *R. petraeum* as susceptible. To repeat these results the author obtained cuttings from a plant of *R. petraeum* var. *hirsutum* at the Royal Botanic Garden, Edinburgh, 23rd May, and of

RESULTS OF INOCULATING THE VARIETY NORWEGIAN RED DUTCH AND
CHECK PLANTS WITH *Cronartium ribicola*.

[Types of infection: 1 ○, immune; 2 ●, resistant; 3 ●, susceptible. Relative abundance of uredina: —, trace; —, slight; ., moderate; L, heavy; and . ., very heavy.]

Species or Variety inoculated	Number of Plants inoculated	Leaves inoculated		Number of Plants showing on their Spore-producing Leaves the indicated abun- dances of Uredina.				Number of Plants of Specified Infection Type.		
		Number	Per cent infected	—	—	+	++	○	●	●
Norwegian Red Dutch	18	181	0	..	..	..	..	18	0	0
American Red Dutch ²	20	199	100	0	0	17	3	0	0	20
<i>R. aureum</i>	3	36	100	0	0	0	2	1	0	3
<i>R. nigrum</i>	1	21	100	0	0	0	0	1	0	1

¹ A full explanation of the symbols is given in the reference (4).

² Telia were observed, 13th May, on leaves of the American Red Dutch; they formed within three weeks. Abundant telia were observed, 15th June, on naturally infected leaves of the plant of *R. nigrum* used in the first test of the series.

R. petraeum Wulf. from Kew, 19th June 1929, and inoculated these separately with *C. ribicola*. The cuttings were kept standing in water, which was changed frequently, and their cut ends were clipped occasionally to maintain freshness. In the inoculation procedure the cuttings were treated like potted plants. Care was taken, however, to protect the cuttings from the direct glare of the sun. As a check on the experiments young shoots of *R. aureum* were used.

Both the Edinburgh and Kew plants of *R. petraeum* were found to be susceptible to the rust, the fully expanded leaves producing a moderate amount of normal uredinia. While satisfactory results with regard to the production of sporulating uredinia within twelve days were obtained in this type of experiment, it was noted that the relative abundance of spores produced on the leaves of the *R. aureum* cuttings was not so great as that produced on inoculated leaves of potted plants.

One very interesting observation on the type of the infection of leaves of *R. petraeum* was made. Leaves of *R. petraeum* var. *hirsutum*, just behind the growing tip of the shoot, which were not quite fully expanded or had only very recently become so, showed a marked resistance to the rust. This resistance was manifested by a formation of necrotic bits of tissue or flecks in the tissues of the leaf in which spores could not be found.

TYPE OF INFECTION OF THE NORWEGIAN RED DUTCH.

It was observed in the Norwegian Red Dutch that leaves at the base of the plant which had hardened did not show any signs of infection by way of necrotic flecks. Above these fully matured leaves, however, along the median part of the shoot, and just behind the tender, unexpanded leaves at the apex, the leaves showed a pronounced "flecking." Plate XII shows a leaf of the Norwegian currant variety exhibiting necrotic flecks to a moderate degree.

At a later date full histological detail will be given demonstrating the rust fungus mycelium amongst the cells of the leaf, and the protoplasmic condition of the host cells as a result of the attack of the organism. For the present it can be said that the *Cronartium* is able to enter the leaf tissues of

the Norwegian Red Dutch, but it is unable to propagate itself farther and produce spores. Numbers of flecks were examined, but in these spores were not found. It was noted that at the point where the fungus had gained entrance the cells had become necrotic. Associated with the necrosis there occurred a deposition of a tannin-like substance between the cells. About this necrotic core or centre the spongy mesophyll cells, and the palisade cells also, were considerably swollen and generally devoid of their chloroplasts. The general effect of these necrotic flecks in the infected but immune leaf, when held against the light, was to resemble a number of glistening, minute targets with dark "bulls'-eyes" surrounded by more or less distinct circles or haloes of light coloured tissue (Plate XIII). Viewed at an angle, the flecks on the under side of the leaf showed as minute, translucent blisters with darkened centres.

ECONOMIC IMPORTANCE OF THE NORWEGIAN RED DUTCH.

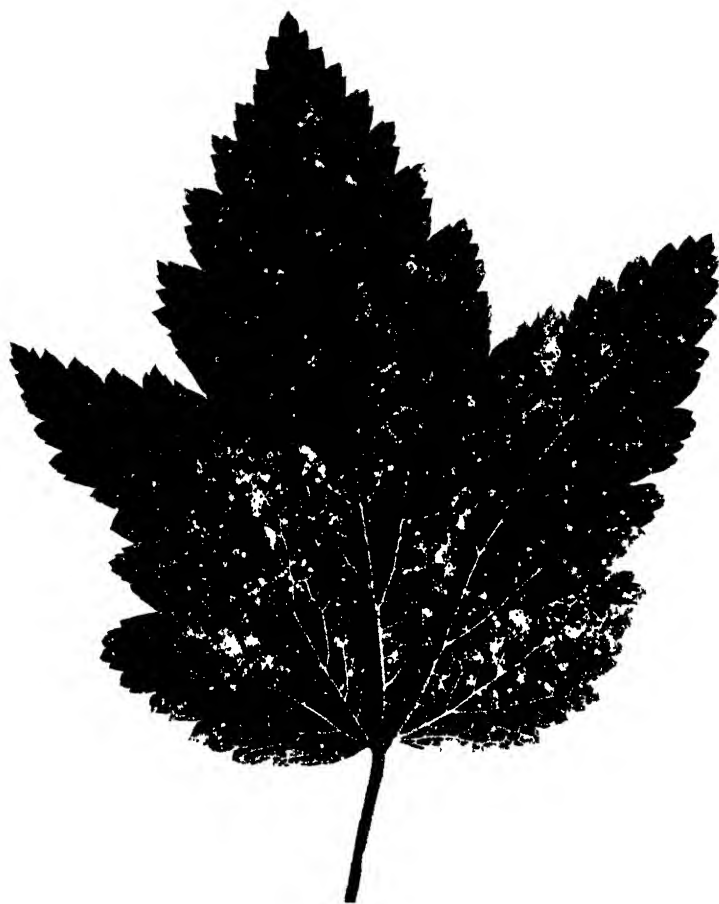
If the Norwegian Red Dutch variety, which has just been tested with such satisfactory results in Scotland under the rigorously controlled conditions imposed by the writer, maintains this character of immunity to white-pine blister rust when introduced into America under environmental and fungus conditions there, it may prove to be a most valuable plant for propagation and utilization in the blister rust control programme of the United States. This European variety gives promise of being a very useful plant for hybridization purposes in evolving other disease immune varieties. In Norway the variety is regarded highly as an excellent and dependable producer of fruit of good quality. The Norwegian Red Dutch currant, however, must be rigorously and thoroughly tested in its new environment, against American strains of *C. ribicola*, before definite claims or statements can be put forth regarding its immunity, and recommendations made for its propagation in the United States.

Throughout this investigation in Scotland the writer was accorded every possible assistance. Particular acknowledgment is made to Professor Wright Smith, Regius Keeper of the Royal Botanic Garden, who generously provided greenhouse space and placed equipment at the disposal of the writer; and

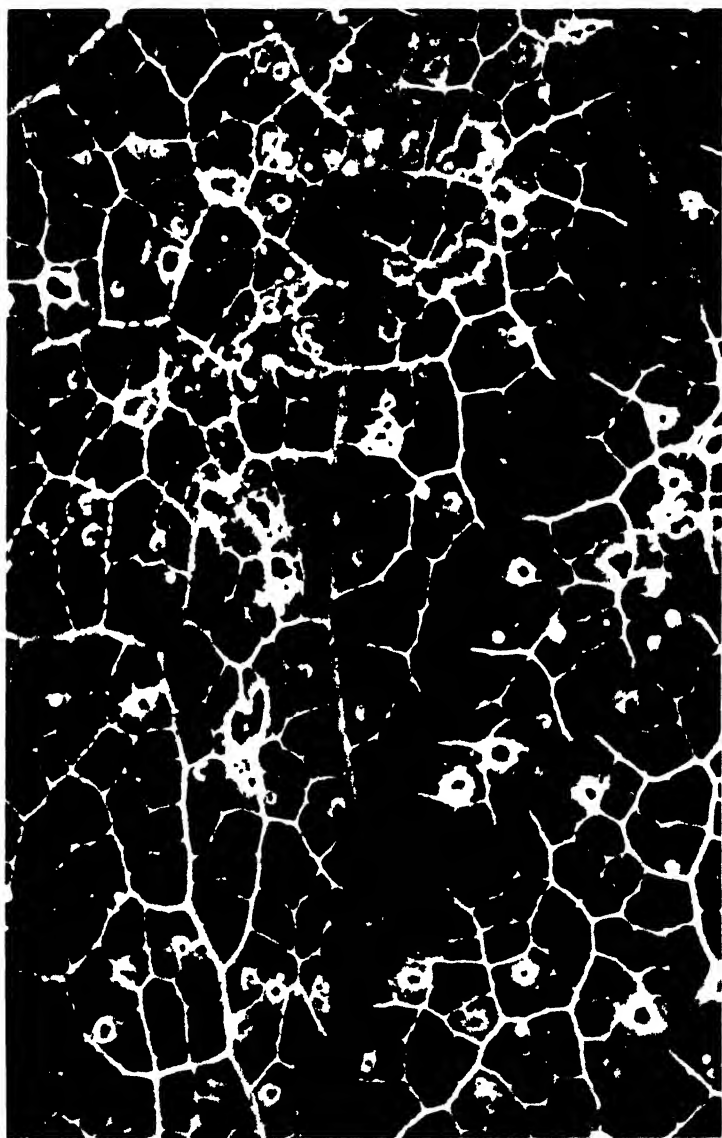
to Mr. Ivar Jørstad, Botanisk Museum, Oslo, who procured for the writer cuttings of the Norwegian Red Dutch through the kindness of Mr. P. Stedje, Pomological Experiment Station, Hermansverk in Sogn; and Professor O. Moen, Agricultural College, Ås, Norway. Thanks are also due to Professor Oscar Hagem, Botanisk Museum, Bergen, for botanical specimens and information on the Norwegian currant variety; to Dr. Hill, Director of the Royal Botanic Gardens, Kew, for fresh specimens of *R. petraeum* Wulf., procured through the kindness of Dr. Malcolm Wilson; to Dr. J. G. Maynard, Agricultural and Horticultural Research Station, Long Ashton, Bristol; and Mr. Paul Thayer, U.S.A., for information on the Norwegian currant variety; to Mr. J. Murray of the Forestry Commission, and Mr. F. R. S. Balfour, Dawyck, Stobo, Peeblesshire, Scotland, for the specimens of diseased pine received through the courtesy of Dr. Wilson; and to Mr. L. B. Stewart, Assistant Curator of the Royal Botanic Garden, Edinburgh, under whose direction the plant cuttings from Norway were propagated.

BIBLIOGRAPHY.

- (1) BERGER, A.: A Taxonomic Review of Currants and Gooseberries. N.Y. State Agr. Exp. Station, Tech. Bull. 109 (1924).
- (2) BUNYARD, E. A.: History and Development of the Red Currant. Journ. Royal Hort. Soc., xlii (1917), pp. 260-270.
- (3) DETWILER, S. B.: Black Currant spreads White Pine Blister Rust. U.S. Dept. Agr., Misc. Pub. 27 (1928).
- (4) HAHN, G. G.: The Inoculation of Pacific Northwestern Ribes with *Cronartium ribicola* and *C. occidentale*. Journ. Agr. Res., xxxvii (1928), pp. 663-683.
- (5) SOMMERVILLE, W.: *Peridermium Strobi*, the Blister of Weymouth Pine. Quart. Journ. For., iii (1909), pp. 232-236.
- (6) SPAULDING, P.: Investigations of the White Pine Blister Rust. U.S. Dept. Agr., Bull. 957 (1922).
- (7) — White Pine Blister Rust: A Comparison of European with North American Conditions. U.S. Dept. Agr., Tech. Bull. 87 (1929).
- (8) THAYER, P.: The Red and White Currants. Ohio Agr. Exp. Station, Bull. 371 (1923).
- (9) TUBEUF, C. F. von: Das Schicksal der Strobe in Europa. Zeitschrift f. Pflanzenkrankheiten u. Pflanzenschutz, xxxviii (1928), pp. 1-32.



Leaf of immune Norwegian Red Dutch variety showing necrotic flecks. ($\times 2$.)



Necrotic flecks in leaf of immune Norwegian Red Dutch currant. ($\times 10$.)

NOTES ON STRAND PLANTS.—III. *SALSOLA KALI* L.

By ISABELLA S. McNICOLL, B.Sc.

(Read 27th June 1929.)

Salsola Kali is a low-growing, annual, herbaceous, bushy strand plant occupying a circular area of ground. It is anchored by a deep pivot root, and the lower shoots lie flat along the surface of the sand. Its epigeal system consists of dorsiventral branches given off radially from a vertical axis, which rarely rises above five centimetres in height. The main axis does not retain its dominance but bends over into a dorsiventral position. The tips of all the branches are ascending.

The leaves are arranged on a two-fifths phyllotaxy, and the internodes are 2–5 mm. in length. They are small, three times as long as they are broad, sessile, succulent, with a spinose tip, and are oriented at right angles to the stem. The stems are relatively thick, 4–5 mm. in diameter, stiff, resilient, and resistant. The secondaries bear tertiary branches given off in two lateral rows. When young they are sub-erect, and as they age, bend over into a dorsiventral position, probably due to gravity, preserving the general dorsiventrality. Each node bears two accessory buds serially arranged, about fifty per cent. of which develop into shoots, the active one being invariably the upper of the pair. The plant dies down in early autumn and propagates and perennates by seeds. The fruits are wind and water dispersed.

The plant is a member of the strand community, and is found on the seaward side of the dunes, also in sandy bays among the white dunes. The conditions of the habitat are hard and determine xerophily and an open community. The plant therefore exhibits xerophilous and sand-binding characteristics. In relation to the water distribution in depth the base of the root is devoid of branches, while the young region has laterals in two rows. Its protective measures against excessive transpiration are shortness of internodes, low growth with resultant density of foliage, smallness of leaves, spinosity, and covering of hairs. The leaves are dorsiventral, bilaterally symmetrical, with a flattened sheathing base and a tip

prolonged into a lignified spine. For the greater part of its length the lamina is cylindrical, but gradually flattening towards the base, with increasing concavity on the upper surface it grades into the sheath. The succulence of the leaves is correlated with the need for conservation of water.

The main stem is sub-erect, rigid, and circular in section of 3-4 mm. diameter. It is slightly ridged and furrowed, the ridges being alternately large and small; the more prominent correspond to the leaf midrib, and are continuous through five internodes. The furrows aligned with the chlorophyllous areas are green, while the ridges are of yellow-green hue. Both furrows and ridges bear epidermal hairs. Adult plants are buried by sand-drifting in autumn, but the fruits and seeds mature underground and retain their vitality.

The plant is one of the pioneers in dune formation. Its epigeal system is the chief sand-binding mechanism. Sand blown up over the latter is stabilised in the network of branches. On decay the plant supplies humus ensuring water retention and ultimately mineral salts to the substrate, thus paving the way for an association progression of grasses such as *Elymus* and *Psamma*.

In the leaf the epidermis is uniform on both surfaces. Ten per cent. of the cells are prolonged into short, conical hairs. The structure of these hairs is as described by Solereder (i, 1028) for Chenopodiaceae. While of general distribution they are more numerous, besides being about twice as long at the basal as at the apical end. The external surface of the hairs is roughened by irregular cuticular excrescences. The hair-producing cells are almost circular in plan; the other cells are regularly hexagonal over the chlorophyllous areas and longitudinally elongated in line with the non-chlorophyllous areas. The epidermal cell walls are thickened, both outer and inner, and there is a well-marked cuticle.

The margins, the upper and lower surfaces of the base aligned with the non-chlorophyllous areas, are without stomata, while elsewhere they are generally distributed. They are transversely placed, flush with the surface, and either circular or elliptical, with circular or slit pore respectively, and situated ten pore diameters apart. The mesophyll is differentiated into peripheral chlorenchyma and central, colourless, aquiferous tissue. The latter preponderates. The chloren-

chyma is in two strata each one cell deep. The outer, a palisade of cylindrical cells with vertical spaces, is twice the depth of the inner cells, which are dodecahedral in shape, forming a compact band without any spaces. The chloroplasts line the inner walls of the latter and the side walls of the cylindrical palisade cells. Solereder (*loc. cit.*, p. 667), describing *Salsola longifolia*, refers to the inner chlorenchyma layer as a starch sheath, and also describes a special starch sheath girdling each meristele. The latter appears to be absent, and starch was rarely found in the former tissue in *S. kali*.

The chlorenchyma first appears as a strip on the upper side of the leaf at the base of the spine (fig. I, 2), and rearwards rapidly extends round to form a complete cylinder enclosing the core of colourless tissue (fig. I, 3). As a cylinder it extends back half the length of the shorter leaves and two-thirds in longer. Thereafter it splits into four parts (fig. I, 7). This change is correlated with the passage in the leaf from radial cylindrical to bilateral symmetry. The first break in the cylinder occurs on the under side in the line of the midrib (fig. I, 5), to be followed by others at the leaf margins (fig. I, 6 and 7), and almost immediately thereafter by another on the upper side again aligned with the midrib. The cylinder is now broken up into two upper strands and two lower (fig. I, 8). Rearwards the former rapidly contract and disappear, so that the sheath is devoid of chlorenchyma on its adaxial side (fig. I, 9 and 10). The two lower strands continue on into the base on its abaxial side and course thence right down the stem, after previously contracting to half their original width (fig. I, 11).

In bulk, the aquiferous parenchyma is the predominant tissue of the leaf. Its dimensions and shape change with those of the latter, thus it is a cylinder in its apical part and a sector of a circle in its basal portion. It has no intercellular spaces. Its walls are thin, slightly lignified, and the cell contents highly vacuolated. The cells of hexagonal outline are the largest in the leaf, but vary in size, the largest occupying the region midway between the leaf surface and the midrib. In place of the hypodermal layer of crystal sacs described by Solereder (*loc. cit.*, p. 660) for *S. longifolia*, *S. Kali* has a discontinuous layer of such sacs at the junction of chlorenchyma and aquiferous tissue.

Three stelar bundles after closing up and then separating in the stem ring pass out approximately parallel through the

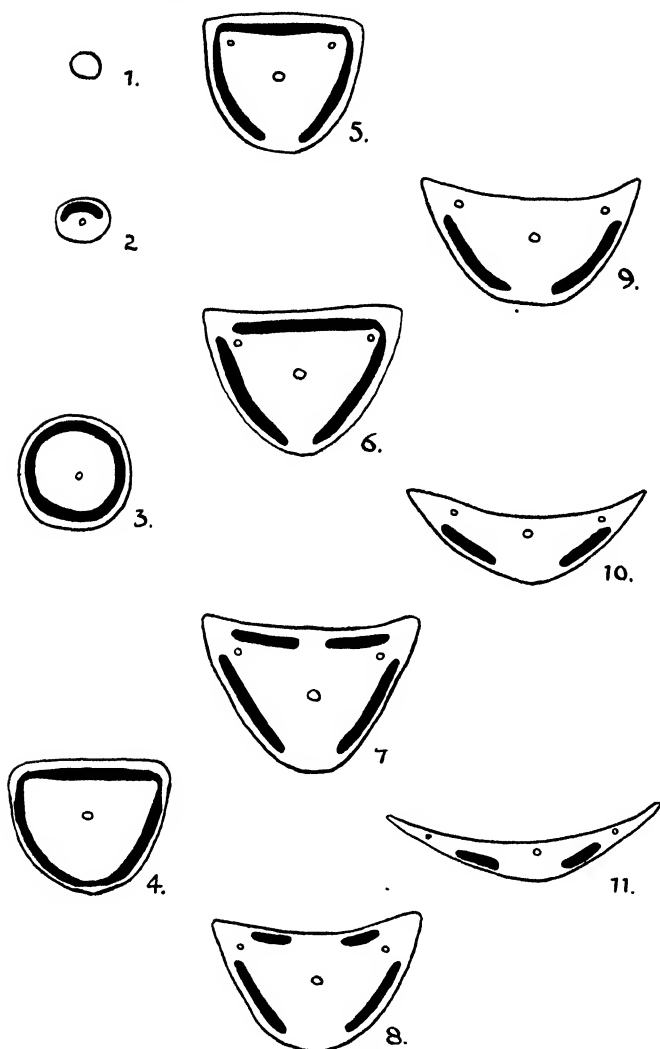


FIG. 1.—Distribution of Chlorenchyma in leaf.

cortex and leaf base, and course through the lamina as a central and two lateral meristeles. The laterals course close to the margin and fade out at half distance, having previously given off adaxial and abaxial branch systems. Those systems

from opposite sides anastomosing constitute a vascular network between the chlorenchyma and the aquiferous core of the lamina. To this system contributions are also made by the midrib, which branches at its apical termination but not elsewhere.

The general plan of the stem is typically dicotyledonous. The observations on the structure of the epidermis, of the stomata with their transverse orientation and their subsidiary guard cells correspond with those of Solereder (*loc. cit.*, pp. 658 et 662). The cells over the ridges are usually elongated, while elsewhere they are isodiametric in surface view. The ridges are formed of strands of collenchyma. These as stated are associated with the midribs of the leaves, and extend downwards through five internodes. Alternate with them are the pairs of chlorenchyma strands identical with those of the leaf. These passing in from the abaxial side of the leaf run a parallel course in the stem for five internodes, coalescing and fading out in the last internode, whereafter at the adjacent node two new strands enter from the leaf.

The other cortical tissue is parenchymatous, the inner part specialised as a starch sheath two cells deep. The primary bundles, of collateral open type, fifteen in number and of unequal size, are separated by wide medullary rays. They are surrounded by a common pericycle and enclose a pith of parenchyma cells increasing in size centripetally. The stem has a persistent epidermis and forms no periderm. The type of secondary thickening in *Salsola* undetermined by De Bary (2, p. 590) appears to come under his type 4, where the primary cambium is temporary and the secondary permanently active. Very early the former becomes active, and produces a small amount of xylem and phloem. During this development the medullary rays are lignified. Secondary cambial arcs arise in the pericycle adjacent to the phloem and opposite the primary bundles. These unite to form a complete cylinder. This, the secondary cambium, remains permanently active, and lays down in regular order radial rows of lignified parenchyma and closed collateral bundles. This bundle arrangement is as described by De Bary (*loc. cit.*, p. 593). They alternate both radially and tangentially with intermediate tissue, and are arranged in irregularly concentric zones. Associated with the increase in secondary tissue is a decrease in the size of the pith core and a crushing of the cortical tissues.

With reference to the root of *Salsola*, Fron (3, p. 565) has stated that the primary structure is asymmetrical due to the mechanical compression of the cotyledons against the primary root in the seed. This asymmetry is exaggerated by secondary thickening. In his account of the latter (Fron, 4, p. 178), he describes the secondary cambiums arising in alternating pairs, one pair parallel, the other at right angles, to the primary xylem bar, and thereafter linking up. My observations go to show that while these cambiums arise in pairs, these are always oriented parallel to the primary phloems, and that the primary stele which is diarch has a symmetrical not an asymmetrical bar of xylem. Normal secondary growth begins early, through the activity of an ordinary primary cambium originating as usual between the primary phloems and the primary xylem bar. The product of this cambium is intermediate, lignified, pitted prosenchyma and secondary vasa, some of which are in direct contact with the primary xylem bar (fig. II, 1). In consequence of this development the cambium is pushed outwards, and at the same time pericyclic contributions to it are laid down around the ends of the primary xylem bar, so that a cylinder results (fig. II, 2). Externally the cambium produces secondary phloem, which brings about the flattening, and ultimately the crushing, of the primary phloem elements.

In the inner layer of the pericycle, opposite the primary phloem strands, two secondary cambial arcs are organised (fig. II, 2). This behaves as a normal cambium, producing lignified prosenchyma in radial rows and tertiary xylem and phloem. The secondary cambium extends laterally, and the two arcs link up on one side, whereafter one end of this cambial arc links up with the primary cambium, and this accounts for the spiral appearance in the young root (fig. II, 3 and 4). Thereafter in succession cambial arcs of pericyclic and later of phellodermic origin are laid down, and one end joining up with the free end of the preceding cambium the spiral arrangement is maintained (fig. II, 5 and 6). At various levels in older roots concentric ring arrangements instead of the spiral system of vascular tissue were met with. This may be owing to the fusion of the two ends of the same cambial system, probably due to a slight unilateral pressure. Double spiral systems also occur. Their origin was not elucidated, but it may conceivably be due to fusion of the ends occurring

on opposite sides alternately. The young root is solid, but the older roots show medullation from proliferation of primary xylem parenchyma.

Anatomy of the Seedling (seven days old).—The average length

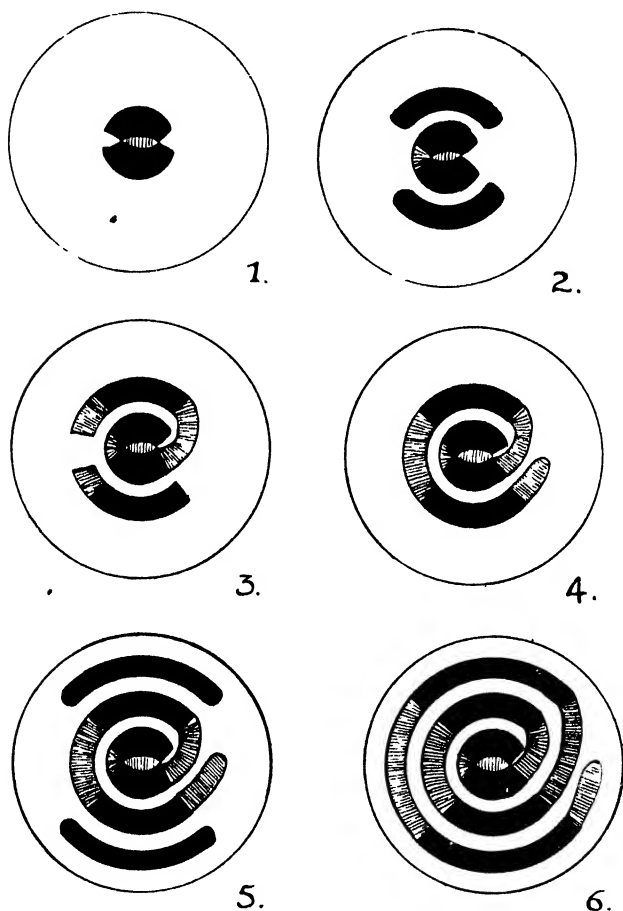


FIG. II.—Anomalous cambium arrangement in root.

of the seedlings from cotyledonary node to root tip is 7.2 cm. The cotyledons are linear, 1.7 by 2 cm., and are oriented horizontally. They emerge, fixed by their apices in the fruit-coat and persistent calyx. They differ from the adult leaves in the following respects :—

(a) In shape, being elliptical instead of circular in section, absence of apical spine and of hairs.

(b) The chlorenchyma is continuous over the rounded apex ; the median breaks precede the marginal ones, while in the adult leaf the adaxial median break follows on that of the marginal.

(c) The trace is of two instead of three meristeles, and there is no cylindrical network.

(d) Crystal sacs are common, but not localised as in the adult leaf.

The hypocotyl shows the following differences :—

(a) Smooth surface without hairs or furrows or stomata.

(b) The cortex is eight cells deep and of isodiametric cells ; an endodermis is present.

(c) Anthocyanin occurs in epidermis and endodermis in greatest concentration, with decreasing amount towards the medio-cortex.

(d) The vascular arrangement in the transition region corresponds to Van Tieghem's Type 3 (*loc cit.*, p. 783), because of the phloem rotation, also to the Cruciform Diarch type of Thomas (6, p. 730). Thomas's description for *Anona* resembles that found here and that of Chauveaud (7, p. 309) for *Amarantus caudatus*, and of Wright (8, p. 398) for *Cakile maritima* exactly correspond to that of *Salsola*.

For subsequent development two sets of seedlings were kept under observation, the one set from seeds which had overwintered naturally in a sand-bed in the garden, and the other from seeds collected in October, dried off, and planted in pots of ordinary soil with a mixture of sand in March, and kept in a frame at a temperature of 45° (night) and 65° (day). While showing resemblances, these also exhibited marked differences. Most noticeable was that the pot seedlings topped the ground a fortnight fully before the others. In both cases, unlike the adult plant, anthocyanin was present, colouring the hypocotyl and the first two epicotyledonary internodes. In respect of leaf and branch arrangement also there was identity. The first epicotyledonary node bore a pair of leaves, each subtending axillary branches ; spiral phyllotaxy begins at the second node with one leaf subtending a branch.

The following is a résumé of the special features of difference

in the two sets at ten weeks. In the natural seedlings the cotyledons lie flat on the surface, the sand having drifted and bedded the hypocotyl. The epicotyledonary internodes are short, and the plant has a rosette appearance. The first two internodes are without the chlorenchyma strands. All the axillary branches are vegetative, and there is no trace of flowers. In contrast, the pot seedlings of the same age had developed somewhat differently. They show considerable elongation of internodes. The hypocotyl is 2 to 3 cm. above ground, and is unable to support the weight of the epicotyledonary portion so that the seedling, top heavy, is bending over, but the elongating shoots are bending upwards. Here the first epicotyledonary internodes show a pair of chlorenchyma strands from each leaf, passing down for part distance. Here also appeared an accessory pair of strands aligned with the point of junction of the pair of leaves at the first node. This exceptional pair is not subsequently repeated. Occasionally in the lower leaves the stem and leaf strands were discontinuous, but continuity was usually established at the second or third node, *i.e.* after the spiral phyllotaxy was established.

Perhaps the most striking difference of all between the two sets was that in the pot seedlings the axillary branches were from the first floriferous in contrast to the vegetative condition of the natural seedlings. At the third epicotyledonary node the solitary leaf or rather bract, with two lateral bracteoles, subtends a solitary sessile flower. These flowers appeared on the first axillary shoots when the seedlings were six weeks old. The accessory axillary buds so characteristic of the adult plant first appeared at the ninth node of the pot seedlings at three months old, while the natural seedlings of the same age showed as yet no trace of them.

The writer wishes to express her indebtedness for assistance in the Botanical Department of St. Andrews University, where this work was done.

SUMMARY.

1. *Salsola* is a pioneer in the seaward advance of the sand dunes. The leaves exhibit xerophilous characters—density of foliage, spinosity, hairs, and succulence.

2. The leaves have a characteristic chlorenchyma distribution correlated with a change in symmetry.

3. The distribution of the chlorenchyma of the stem as well as the surface ridges is related to the structural features of the leaf as well as the phyllotaxy.

4. Secondary thickening in the stem is effected by a temporary primary succeeded by a permanent secondary cambium.

5. The root thickening is anomalous. There is a succession of secondary cambiums linking up partly *inter se*, producing a spiral disposition of vascular tissue.

6. To differences in environment seedlings exhibit reactions in the form of modification of habit and early flowering.

REFERENCES.

- (1) SOLEREDER, H.: Systematic Anatomy of the Dicotyledons. Eng. trans., ii (1908), 1028, 657, 660, 662, 658.
- (2) DE BARY, A.: Systematic Anatomy of Phanerogams and Ferns. Eng. trans., pp. 590, 593.
- (3) FRON, F.: Comptes rendus, Paris, cxxvii (1898), 565.
- (4) — Ann. des Sc. Nat., sér. 8, ix (1899), 178.
- (5) VAN TIEGHEM, PH.: Traite de Botanique, pt. i, 783.
- (6) THOMAS, E. N.: Ann. of Bot., xxviii (1914), 711, 730.
- (7) CHAUVEAUD, G.: Ann. des Sc. Nat., sér. 9, xiii (1911), 309.
- (8) WRIGHT, J.: Trans. Edin. Bot. Soc., xxix, pt. iv (1927), 398.

NOTES ON STRAND PLANTS.—IV. *ARENARIA PEPLOIDES* L.

By ALEXANDER PRATT, B.Sc.

(Read 27th June 1929.)

Arenaria peploides is a low-growing, spreading, herbaceous perennial, with an extensively branching underground shoot system. The green shoots maintain an average vertical height of $3\frac{1}{2}$ inches above the changing sand level. Grown under experimental conditions with constant surface level the shoots elongate, become top-heavy, and lie prone on the surface. This epigeal portion is freely branched, the branches are lateral, and one or two per node, and bear opposite and decussate leaves. It has an average thickness of 3 mm. and a smooth, pale green surface. The nodes are swollen, and the short internodes have their surface marked by two longitudinal, shallow grooves alternating at successive internodes and separating the continuations of the decurrent leaf-bases. The shortness of the internodes, the leaf arrangement, and the absence of petioles ensure density of foliage.

The leaves are 1 mm. thick, 8 mm. long, and 4 mm. broad. They are elliptical in shape, and bear marginally small, rounded teeth, which become progressively smaller from the base to the apex of the leaf. Small rudimentary stipules at the point of union of the connate leaf-bases are in series with these marginal teeth. The leaves are succulent, emerald-green, and acquire a yellow hue with age. They are bilateral and dorsiventral, suberect when young, but later horizontal. Their acute apex has a slight downward tilt, which may become more marked with age. The midrib is outlined by a keel on the under surface and a groove on the upper, less marked in the older leaf.

The subterranean axes average 3 feet over all, and ramify in all directions through the sand. There is a gradual elongation of internodes corresponding with the depth. They are cylindrical, light brown, slightly rough on the surface, and have an average thickness of 2 mm. Each node bears small, paired buds, and there is a progression of oval, sessile buds to minute, stalked buds on passing from ground level to the deeper layers of soil, probably correlated with seasonal

temperature differences according to depth. A limited number of these buds elongate into lateral branches, whose apices in time, bending upwards, become the green, leafy shoots. The bud veneration is imbricate and the ptyxis plain. In the scales and young green leaves of the buds crystals of calcium oxalate, solitary and rosetted, occur in the mesophyll. The root system is adventitious, the rootlets arising singly or in whorls at the nodes. Some of these are thin and delicate, others limited in number and confined to the deeper layers are stout and externally resemble the branches of the hypogeal stem.

For membership of the strand community the plant possesses the following xerophilous equipment: extensive hypogeal shoot system in relation to anchorage and stabilisation of the soil, low growth, density of foliage, and succulence in relation to water economy. It is in the foremost line of sand-binding pioneers concerned in the seaward advance of the sand dunes. As the surface level of the sand rises owing to drifting and more and more of the plant is buried, the subterranean anchoring and stabilising system is amplified, while by corresponding elongation of the buds the green foliage system tops the soil by a few inches. The result is a small hummock around each plant. This was experimentally tested in a sand bed in the garden over a period of nine months.

HISTOLOGY.

The epidermal cells of the leaf are larger on the shade than the light side. The exposed wall of the upper epidermis is nearly twice as thick as that of the lower epidermis, but a well-marked cuticle is present in both. The small teeth previously referred to are each composed of a core of three cells covered by an epidermis whose cells are larger than elsewhere. The stipules are non-vascular and resemble the teeth in structure.

The stomata are flush with the epidermis, and the outer vestibule is contracted by cuticular outgrowths from the adjacent cells. They are equally distributed over the basal third of both surfaces, but are twice as numerous on the apical two-thirds of the lower epidermis as on the corresponding areas of the upper epidermis. The stomatal system

is broadly oval, with longitudinally oriented slits, and the inter-stomatal distance is about twenty pore-diameters.

The mesophyll is differentiated into chlorenchyma and a core of colourless parenchyma, both tissues being three cells deep. The chlorenchyma is a cylinder discontinuous on the under side in line with the midrib, where the gap is filled by a longitudinal, abaxial, vertical flange of colourless parenchyma, an extension from the central aquiferous tissue. The leaf-base is solely of the colourless parenchyma.

The chlorenchyma is a loose tissue of cylindrical cells with numerous vertical intercellular spaces. The aquiferous tissue is compact, of isodiametric cells with few and small air-spaces. The former is rich in chloroplasts, which become successively fewer in the cells of the inner layers until in the inner parenchyma only a few sporadic grains are present.

The leaf trace is a solitary, closed, collateral meristele, leaving the stem stele three bundles distant from its neighbour, that passes into the opposite leaf. Traversing the cortex of the stem undivided it gives off two lateral branches in the leaf-base, which course on as the marginal strands of the lamina. The midrib gives off lateral branches in one plane throughout its course; these latter branch again and form a network extending between the two marginal strands. The three main strands converge to a brush-like ending at the apex, where there is an epithem hydathode occupying a sub-marginal position on the abaxial side distant 2 mm. from the actual tip. The water pores, five in number, are similar in size and shape to the ordinary stomata, except in having no cuticular outgrowths. The elements of the xylem and phloem are of the normal type. In the material examined some of the vasa contained a zoogloea, presumably bacterial, but this was not fully investigated. Each meristele is girdled by an endodermis, one cell deep, containing starch as described by Solereder (*Anatomy of the Dicotyledons*, vol. i, Eng. trans., 1908, p. 108).

Crystallogenous sacs are distributed throughout the central aquiferous tissue as well as in the chlorenchymatous area next the marginal veins. Each sac contains one sphaero-crystal of calcium oxalate, which occupies two-thirds of the cell. The sac-wall is cellulosic and a protoplast is present.

The length of the epidermal cells of the stem is constant, but their width varies according as they are in the groove

or on the ridge, those in the former position being five-sixths the size of the latter. Some cells contain solitary crystals of calcium oxalate of variable form, such as tetragonal pyramids,

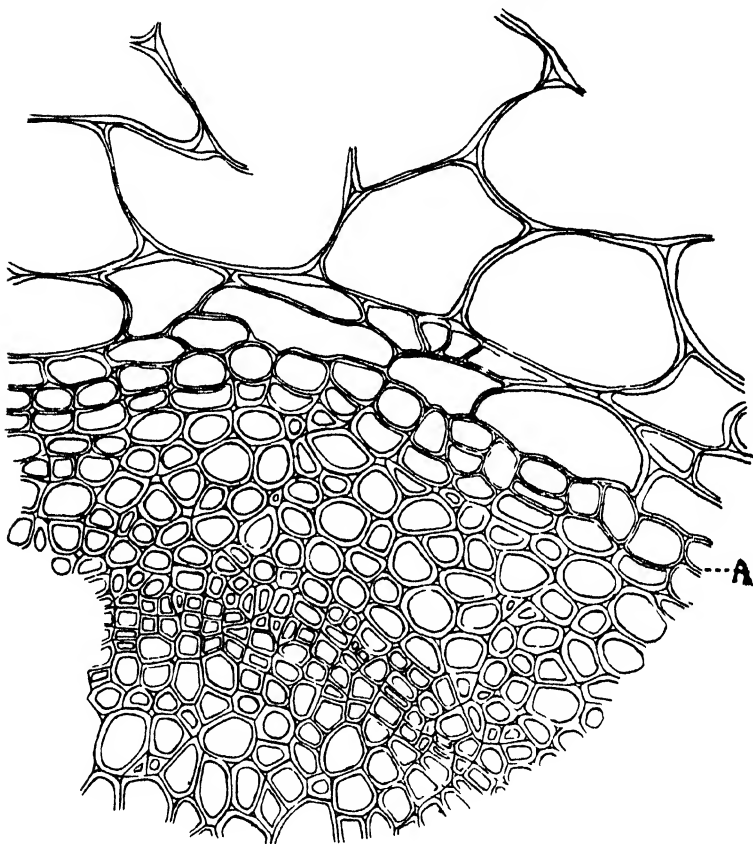


FIG. 1.—Hypogaeal axis showing the endodermal origin of the phellogen A. ($\times 300$)

monosymmetric rhombohedrons, twin crystals, and combinations of pyramids and prisms.

The outer epidermal wall is thick with a wrinkled cuticle accounting for half the depth. The stomata, otherwise like those of the leaf, differ in being slightly raised above the general surface and in being fewer in number, approximately one-twentieth occurring per unit area. The cortex is a cylinder, nine cells deep; the cells, cylindrical, vary in size, the larger

ones being characteristic of the medio-cortex. The tissue is compact with few, small, evenly distributed spaces. The majority of the cells contain crystals similar to those of the epidermis. The starch sheath is one cell deep; its cells are rectangular, with their long axis longitudinal. A few of them

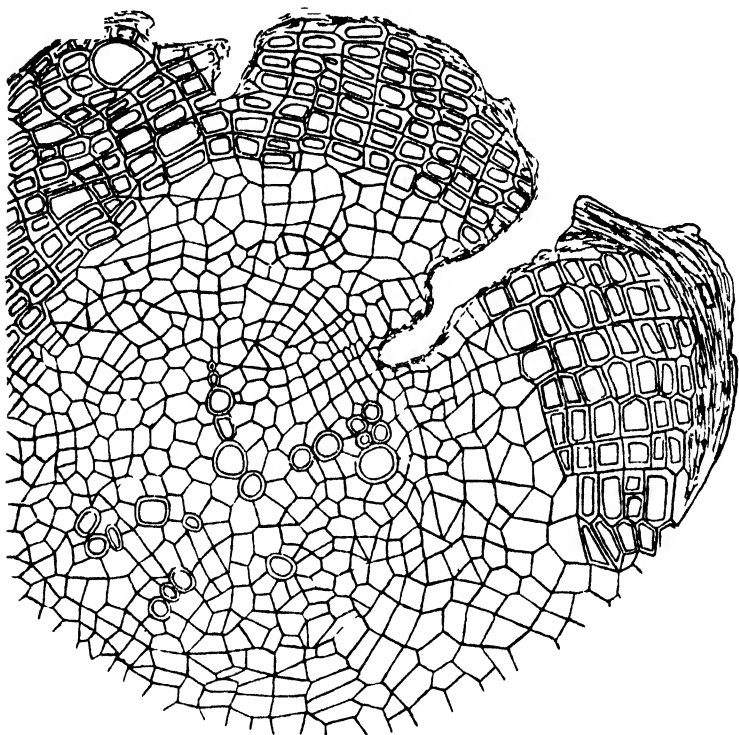


FIG. 2.—T.S. root showing secondary thickening and periderm formation. ($\times 300$)

contain radiating masses of needle-shaped crystals of calcium sulphate. Their walls are lignified, and the radial walls have the characteristic strip. Brick and Peterson, quoted by Solereder (*loc. cit.*, p. 109), describe a pair of stereom zones in the cortex of the stem, viz. a hypodermal of sclerenchyma and an inner of sclerotic parenchyma. They record no endodermis. In the material examined there was found an endodermis internal to which was a collenchymatous tissue, eight cells deep, but no evidence of either stereom system of these writers. The walls of the cortical cells, too, proved to

be cellulosic and not lignified as these investigators state. The cells are longitudinally rectangular, and are all rich in calcium oxalate crystals similar to those of the epidermis.

The vascular system of the stem is a medullated monostele of eight open, collateral bundles separated by narrow rays, two cells broad, later becoming indistinct. Secondary thickening from a primary cambium follows the normal course. As in the leaf, so here a zoogloea occasionally occurred in the tracheae.

In internal structure the hypogeeal axes resemble the epigeal, except that the former have a periderm, and there is an entire absence of the crystal sacs so abundant in the latter. The phellogen appears to be of endodermal origin (fig. 1). This would correspond substantially to the position described for it by Douliot (Solereider, *loc. cit.*, p. 109), who states that it arises on the inner side of the inner stereom, cortical zone. The phellogen products are normal, phellem externally, and collenchymatous phelloderm internally.

In its primary structure the root exhibits no very special features. The endodermis and pericycle are each one cell deep. The stele is solid diarch, and secondary thickening is normal. The only noteworthy feature is that the pericyclic phellogen precedes the stelar cambium in activity, and forms a broad cylinder of phellem externally, and a collenchymatous phelloderm internally (fig. 2).

The writer has to express his indebtedness for facilities and assistance afforded him in the Botanical Department, St. Andrews University, where this investigation was carried out.

SUMMARY.

1. *Arenaria peploides* is one of the pioneer plants in the process of sand-binding and dune formation, its special equipment being its extensive underground shoot system of perennial duration.

2. Its roots are of two kinds, thin and delicate, and stout and longer lived respectively, the latter closely resembling the hypogeeal branches.

3. It exhibits no special anomalous features in the anatomy of its organs; roots and underground axes have a periderm, in the former originating in a pericyclic, in the latter in an endodermal phellogen.

4. The leaves show some xerophilous features, viz. aquiferous tissue and constriction of the stomatal aperture by cuticular growths. On the other hand the stomata are flush or slightly raised.

5. Crystals of calcium oxalate are a feature, being common in the aquiferous tissue of the leaf as sphaero-crystals, and in the epidermis, cortex, and collenchyma of the stem as solitary crystals of various forms.

SEEDLING ANATOMY IN THE GENUS MESEMBRYANTHEMUM.
By CHRISSY I. KEAN, B.Sc.

(Read 27th June 1929.)

The literature dealing with the seedlings of *Mesembryanthemum* is very scanty. They are described by Lubbock (1) as succulent, with the cotyledons broad or narrow and having a rounded apex. More recently they have been described and classified by N. E. Brown (2). "I do not know," he writes, "of any genus or group of genera in which the evolution of one species from another and very dissimilar group can be so well shown as by the study of the development of seedlings of various species of different sections of *Mesembryanthemum*." He gives four types of seedling.

1. The cotyledons are spreading, thin or thickened beneath, and the first leaves are entirely different. The majority of the true *Mesembryanthemum* species belong to this group.

2. The two cotyledons give a half-globose body, slightly depressed across the flattened top. The first leaves are also half globose, but unlike the cotyledonary body, e.g. *M. testiculare*.

3. The cotyledons are as in 2, but the subsequent growth is a single ovoid body with a tiny orifice, e.g. *M. oviforme*.

4. The cotyledonary body and subsequent growths differ but slightly, e.g. *M. pseudotruncatellum*.

The internal structure has been worked out by Hill and de Fraine (3), who give two types. 1. The cotyledons form a short tube, e.g. *M. crystallinum*; and, 2, they are joined by their ventral surfaces for most of their length, e.g. *M. linguiforme*. In certain species these workers find that the protoxylems of the cotyledonary strands are exarch before the bundles enter the hypocotyl; in others, e.g. *M. rhomboideum*, the protoxylems are not fully exarch, and are sometimes practically endarch, but this feature is variable. In *M. Bolusii* and *M. linguiforme*, the largest and fleshiest seedlings, the central bundles of the cotyledons are, for some distance above the cotyledonary node, surrounded by an irregular endodermis, one, two, or three cells deep.

Among his special types Chauveaud (4) deals with *M. crystallinum*, of which he writes: "At the base of the cotyledons

the continuation of the vascular bundle is represented only by the last of the exarch vessels, deep-seated between the two half phloems. On either side of these exarch vessels intermediate and superposed vessels are developed."

In the present instance seeds of twenty-five species were available, and of these eighteen germinated. The first crop was sown in December, and germinated in fourteen to sixteen days, but in a spring sowing germination occurred in eight days. In both cases the percentage of viable seeds was the same for any particular species, but varied greatly in different species. Ninety-five per cent. were viable in *M. linguiforme*, *M. edule*, and *M. aequilaterale*; 90 per cent. in *M. laeve*, *M. scapigerum*, and others. There were no intermediate percentages; from 90 per cent. the germination dropped to 12 per cent. in *M. blandum*, and to 5 per cent. in *M. Bolusii* and *M. multiflorum*. An average temperature of 30° C. was maintained throughout. These figures were arrived at from repeated tests.

Growth proceeded very slowly in the winter sowing, the month-old seedlings having only cotyledons with the plumule undeveloped. From the root tip to the apical bud the average length was 17 mm. In spite of the constancy of the temperature in the frame the spring-sown seeds developed much more rapidly, the same stage being reached in five days instead of a month, as was the case in the winter-sown. One pair of leaves had developed at the end of three months in the winter sowing and in fifteen days in the spring sowing. Development then proceeded at about the same rate in the two sets, the winter sowing being a little in advance, but the plants so produced were not quite so healthy as the spring-sown crop. The development of the two sets is shown by the following table of dates:—

	Winter Sowing.	Spring Sowing.
Sown	2nd December	1st May.
Germinated	18th "	9th "
Cotyledons developed	20th "	14th "
First leaves developed	19th April	29th "
Two pairs of leaves	29th May.	

It would appear that temperature in this case cannot upset the seasonal periodicity of the seed.

The seedlings of the different species show a marked resemblance to each other. They differ very slightly in size, have a primary root about 6 mm. in length, an erect epigeal hypocotyl of 9 mm., and a pair of fleshy cotyledons fused together to form a flat disc 4 or 5 mm. in diameter. The cotyledons are in most cases semicircular with the apex rounded, but in a few species the apex is pointed, giving a triangular outline to the leaf. There is a cotyledonary tube 1.5 mm. in length, with the apical bud situated in the depression. The surface of the cotyledons is smooth and shiny, with no trace of wax on the epidermis. The cotyledons do not appear to be joined along their ventral surfaces in any of the species, but, contrary to the view of Hill and de Fraine, are only joined by their bases.

The primary root is very slender, 0.1 mm. in diameter, but there is a marked increase in diameter at the "collet" region, and the hypocotyl, though only 0.7 mm. in diameter, is easily distinguishable from the root. It is colourless or may be pale green at the tip, but in no case was there evidence of anthocyanin in the tissues of the hypocotyl.

The internal structure in every species examined was identical. The primary root is diarch and the hypocotyl is very simple in structure. The epidermal cells of the hypocotyl are elongated, hexagonal in outline, and have clear contents; there are no stomata. The cortex is several cells deep. The cell contents are clear except in the green parts, where a few chloroplasts are found. Rapides are present in rare cases in the cortex and epidermis. An endodermis, one cell deep, occurs in the hypocotyl, but is less pronounced than in the root, where it is two cells deep.

The epidermis of the cotyledons differs from that of the hypocotyl, and in most cases from that of the adult leaf. The cells are irregular in outline, of a type only occurring in the adult leaves of a small number of species. The stomata are less numerous on the upper surface, and subsidiary guard cells are not present, in contrast to the adult leaves, in which these occur in a well-defined group of species. In section the epidermal cells have an exceedingly convex outer wall, every cell thus forming an ocellus. It is these convex walls which give the glittering surface apparent in the cotyledons of every species. The crystal layer which is characteristic of the

outer epidermal wall of a large number of adult forms is entirely absent in the cotyledons.

The mesophyll is chlorophyllous throughout, with no typical aqueous tissue. The lower mesophyll is spongy, gradually merging into palisade towards the upper surface. Tannin sacs have not been observed in any of the species examined (Trans. Bot. Soc. Edin., xxx, pt. 1, p. 37), but raphides occur abundantly in both epidermis and mesophyll. Calcium malate crystals appear, as in the adult leaf, in alcoholic material (Trans. Bot. Soc. Edin., xxx, pt. 1, p. 43).

The vascular system of the adult leaf is of two types, and these must be indicated before the vascular anatomy of the seedling can be fully understood. In certain leaves the system arises from a single leaf trace, while in others the trace is composed of three separate bundles.

VASCULAR ANATOMY OF THE HYPOCOTYL.

TYPE I.—Adult leaf with *one* bundle in the leaf trace.

(a) *Five-day-old Seedling*.—The stele of the hypocotyl is identical with that of the root for the greater part of its length. Transition from root to stem structure occurs from 1 to 2 mm. below the cotyledonary node, and is not complete at the base of the cotyledons. It is therefore of the "High Type" of Compton (5). In the lower part of the hypocotyl the stele is diarch with two exarch protoxylems, thus forming a bar of primary xylem in the cotyledonary plane, and flanked by an arc of phloem on either side, as in fig. I, 1, thus conforming to the "Diarch Cruciform Type" of Thomas (6). A little higher up, the xylem bar shows a tiny lateral protrusion on one side near the protoxylem, and a similar protrusion on the other side towards the opposite protoxylem (fig. I, 2). Still later, a second pair of protrusions appear opposite the first, so that there are now two pairs on opposite sides of the primary xylem bar (fig. I, 3). The next stage shows the phloems dividing to give a phloem area opposite each protrusion (fig. I, 4). The two halves of each original phloem area then rotate towards opposite poles, and at the same time the protoxylems become inconspicuous (fig. I, 5). The transition is therefore of Type 3 of Van Tieghem (7), since the phloems alone rotate. Pith formation now occurs by

cortical intrusion; the xylem bar divides in the transverse plane, giving two bundles each with two phloem patches, and forming a triad structure (fig. I, 6). This occurs at the base of the cotyledons. The pith increases in size by further intrusion of parenchyma, and the bundles are pushed apart.

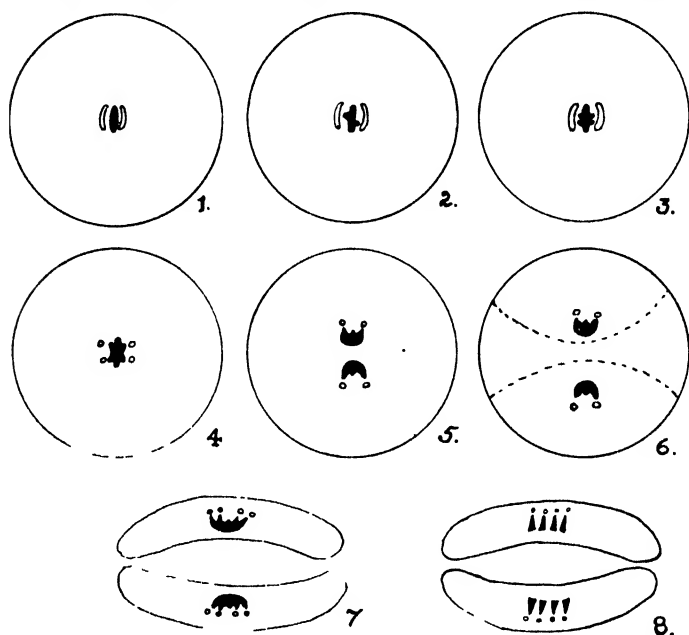


FIG. I.—Development of the stele in the transition region in the five-day-old seedling of *M. aequilaterale*.

1. Primary diarch root. 2-3. Development of lateral protrusions. 4. Division of phloem. 5-6. Rotation of phloems and beginning of medullation. Protoxylems become inconspicuous. 7. Development of lateral strands in the base of the cotyledons. 8. Separation of vascular strands and disappearance of protoxylem a little way up from the base of the cotyledons.

As the bundle passes into the cotyledon, lateral strands of xylem and phloem appear as branches of the central strand, with which they remain in contiguity for a considerable distance through the cotyledon (fig. I, 7). The endarchy at the top of the hypocotyl described by Hill and de Fraine (*loc. cit.*) has not been observed.

The protoxylem disappears in the cotyledon just above the base, and typically there are four collateral strands forming the central meristele (fig. I, 8). The venation of the cotyledon

is asymmetric but approximating to bilateral. A strand may be given off first to the left, and a little farther up another to the right. The two remaining strands pass forward almost to the apex, where one passes out laterally and the other remains as the midrib, which may or may not divide again. The lateral branches subdivide, and ultimately form a reticulum. No free endings were observed, the branches being linked up in a marginal vein passing right round the leaf. At the base this marginal branch links up on either side with the corresponding branch from the opposite cotyledon.

(b) *Fifteen-day-old Seedling*.—The hypocotyl at this stage shows no change until just below the cotyledonary node, where the triad gives off a pair of small bundles (fig. II, 1). These rotate outwards and meet the pair from the opposite triad in the median plane (fig. II, 2). They do not coalesce but divide again, giving four to six collateral strands, one side usually having one more than the other (fig. II, 3). By this time the cotyledonary traces have passed out. The two outermost strands from each bundle separate off and approach each other as in fig. II, 4, the remaining strands having also diverged. As in the cotyledons, the two lateral strands form the trace for the next pair of leaves, and divide as before (fig. II, 5 and 6). The strands which form the trace for the first pair of leaves have come together again at this stage preparatory to passing out (fig. II, 6). Fig. IV, 1, shows the course of the vascular strands to the cotyledons and to the first and second pairs of leaves.

TYPE II.—Adult leaf with *three* bundles in the leaf trace.

The five-day-old seedling is identical in structure with the previous type. The cotyledons have only a single leaf trace, and the very young first leaves which are sometimes present at this stage have only a single leaf trace also, but as the leaf matures the triple trace is developed.

The development of this type of leaf trace can be studied in the fifteen-day-old seedling, where the first leaves are about an inch in length. Before passing out, each cotyledonary bundle gives off a pair of branches as before (fig. III, 1, 2, and 3). These join up to form the trace for the next pair of leaves, and give off a pair of branches in exactly the same way as in the previous type (fig. III, 4). When these have joined up the trace gives off a second pair of branches (fig. III, 5),

which form the lateral meristeles of the second pair of leaves. Up to this point the trace of the first pair of leaves is still

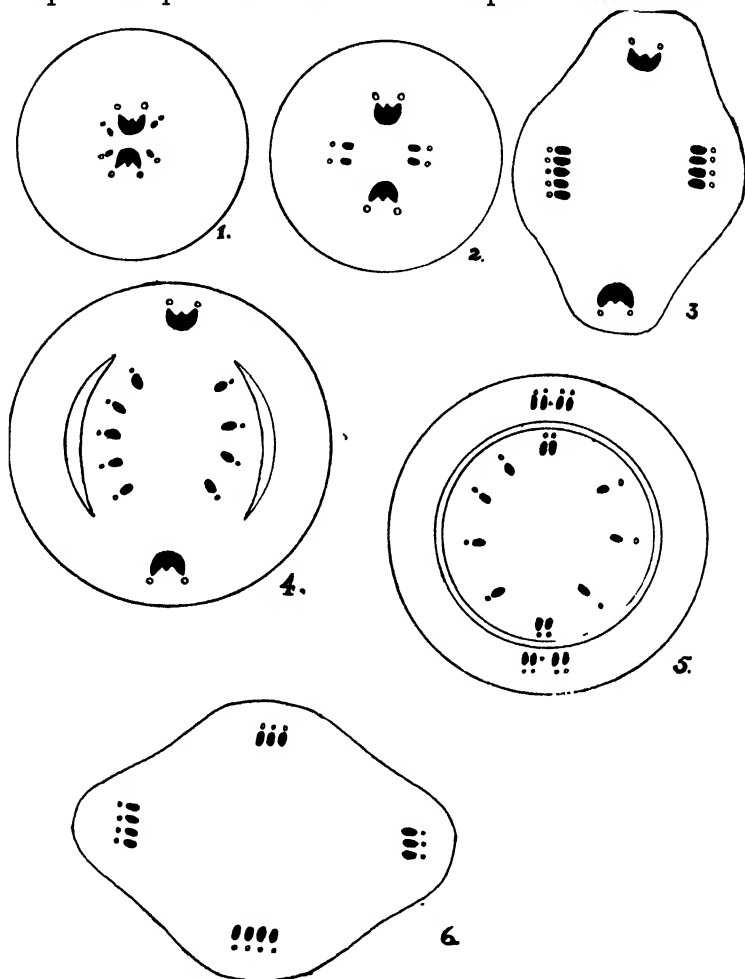


FIG. II.—Development of the stele in the fifteen-day-old seedling of *M. acutilateralis*, from the hypocotyl to the base of the first leaves.

1. A pair of lateral strands separate off from each cotyledonary bundle.
2. Lateral strands come together.
3. Lateral strands divide to give four or five strands.
4. Strands separate from each other as cotyledonary trace passes out.
5. Outer strands at each side come together and form trace for second pair of leaves.
6. Remaining strands pass out as traces to the first pair of leaves.

single, and to produce lateral meristeles it gives off a third pair of branches just before passing out (fig. III, 6).

This condition only occurs in relation to the first pair of leaves; the second and all the succeeding pairs show a different development of the triple trace. As has already been shown, the second pair of branches from the first trace

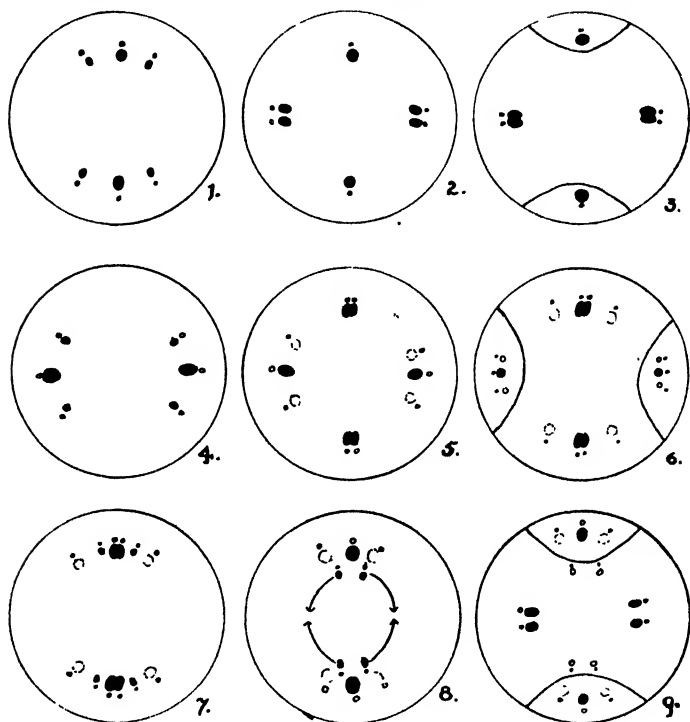


FIG. III.—Development of the stele of a seedling of *M. linguiforme*.

1-3. Cotyledonary node (as in *M. acquilatralc*). 4-6. Up to first node. First pairs of strands given off from central traces for second pair of leaves. Second pairs of strands form laterals for second pair of leaves. Third pairs of strands form laterals for first pair of leaves. 7-9. Up to second node. First pairs of strands give traces for third pair of leaves, and second pairs of strands laterals for third pair of leaves.

forms the lateral meristemes for the second pair of leaves. Between the central and lateral meristemes of this second trace a new pair of branch bundles appear (fig. III, 7). These go to form the central meristeme of the third trace, and pass behind the laterals of the second pair (fig. III, 8). A second pair of bundles is developed in the same position as the first, and is left behind, when the trace passes out to form the laterals for the third trace (fig. III, 9). This is exactly the same

condition as was found when the second trace passed out, and recurs at the development of each succeeding pair of leaves.

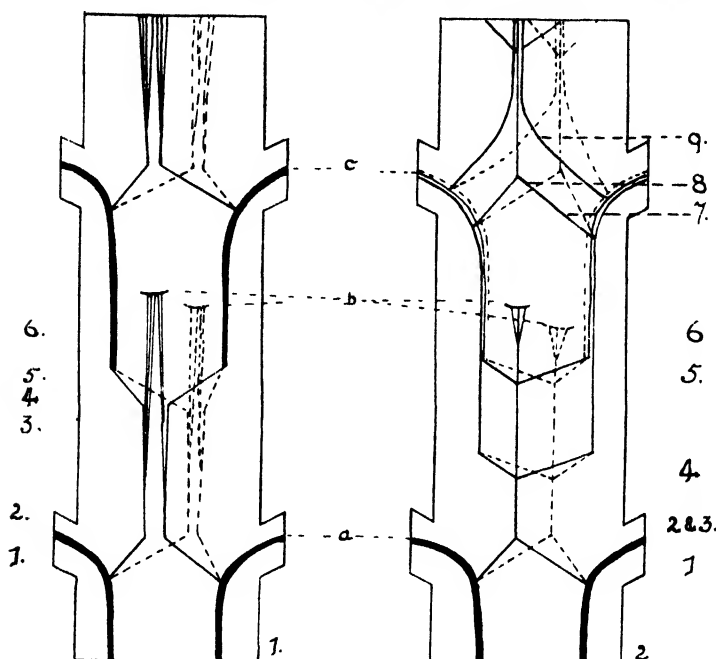


FIG. IV.—1. Longitudinal section of hypocotyl and first and second internodes of *M. aquilatale*, showing course of leaf traces. (a) Cotyledonary node; (b) first leaves; (c) second leaves. The numerals to the left show the levels corresponding to the diagrams in fig. 2.

1. Cotyledonary trace gives off a pair of bundles. 2. Bundles come together. 3. Divide up into separate strands. 4. Strands separate from each other. 5. The two outer strands of each set coalesce to give traces for second leaves. 6. First leaves begin to pass out. Course of bundles in second internode is identical with that in first.

2. Longitudinal section of hypocotyl and first and second internodes of *M. linguiforme*. Numerals to the right correspond with those of fig. 3.

1. Pair of bundles given off from cotyledonary trace. 2-3. Fusion of lateral bundles to give trace for first leaves (separation into strands not shown in diagram). 4. Trace gives off a pair of bundles to give central meristele of second leaves. 5. A second pair of bundles given off to give laterals for second leaves. 6. A third pair of bundles given off to give laterals for first leaves. 7. Central bundle of trace for second leaves gives off a pair of branches. They pass inwards to give central meristele for third leaves. 9. A second pair of branches give laterals for third leaves.

The course of the bundles in the first and second internodes is shown in fig. IV, 2. To avoid confusion the strands in the bundles are not indicated in this case, but are present to the

same extent as in Type I. In other respects the diagram may be compared with fig. IV, 1.

M. crystallinum, the species described by Chauveaud, belongs to Type II. The lateral strands which he states are developed late are already present at the base of the cotyledons, and, in fact, are the first evidences of transition in the hypocotyl, being developed from the lateral protrusions as stated above.

The evolution of very diverse adult forms of plants from seedlings differing but little in appearance is well shown, in accordance with Brown's (*loc. cit.*) statement, but the seedlings themselves differ so little as to be grouped as one type. They only show varying degrees of succulence, and differ slightly in the shape of the cotyledons.

The first leaves in many cases are not of the adult type either in form or structure. In *M. laeve* the first leaves are of the adult form, but a crystal layer in the outer wall of the epidermis is only developed with the second pair of leaves. In *M. caulescens* the first and second pairs of leaves are of the *M. laeve* type, and in *M. deltoides* the first pair are like those of *M. laeve*, the second pair like those of *M. caulescens*, and the third pair have the typical leaf form. The crystal layer in the outer wall of the epidermis may be developed in the first pair of leaves as in *M. Brunthaleri*, or much later as in *M. multiflorum*, where it appears for the first time in the fifth pair of leaves. In the same way subsidiary guard cells may not be developed till the third or fourth pair of leaves is produced. The development of hairs in *M. crystallinum*, described by Heckel (8), is also an example of the delayed formation of adult characters; the typical bladder is only developed with the third pair of leaves. There is no definite order of appearance of the adult characters. Sometimes the crystal layer and the stomatal characters appear in different pairs of leaves. The adult form of the leaf is usually found in the second or third pair of leaves, but the epidermal characters may not be typical till the fifth pair is produced.

The structure of the seedlings is so constant in the species examined that it is impossible to derive, from the stele at least, any points of phylogenetic importance. Tetrarchy and triarchy exist in an occasional plant, but were not found in the seedling. This, however, might suggest a reversion to a more primitive tetrarch type. At the same time, as the

seedlings are very small, the diarchy, so prevalent, may be in relation to size as stated by Compton (*loc. cit.*).

SUMMARY.

1. The seedlings are all succulent, and vary only slightly in external form.

2. The epidermis of the cotyledons is of the primitive dicotylous type, with no crystal layer and no subsidiary guard cells.

3. The stele is diarch, of the "Diarch Cruciform Type" of Thomas, with transition of the "High Type" of Compton, and Type 3 of Van Tieghem.

4. In every case the cotyledons have a single leaf trace.

The writer wishes to thank Professor R. A. Robertson of St. Andrews University for his constant interest in the work, and to acknowledge her indebtedness to Professor Wright Smith and to the gardens of La Mortola for gifts of seeds.

REFERENCES.

- (1) LUBBOCK : On Seedlings, ii, 1892, 13-16.
- (2) BROWN : Gardeners' Chronicle, ser. 3, lxx (1921), 173 and 207.
- (3) HILL and DE FRAINE : Ann. of Bot., xxvi (1912), 187-188.
- (4) CHAUVEAUD : Ann. de Sc. Nat., sér. 9, xiii (1911), 311.
- (5) COMPTON : Journ. Linn. Soc., xli (1912), 66-67.
- (6) THOMAS : Ann. of Botany, xxviii (1914), 697-698.
- (7) VAN TIEGHEM : Traite de Botanique, i (1891), 782.
- (8) HECKEL : Compt. Rend., xcvi (1883), 593.

OBITUARY NOTICES.

WILLIAM GARDNER SMITH.
1866–1928.

By the death of Dr. William G. Smith on the 8th December 1928 the Botanical Society of Edinburgh has lost one of its most distinguished members, a valued friend, and a singularly attractive personality. Elected a Fellow of the Society in 1909, he served for many years on the Council, and for the years 1920 and 1921 he occupied the Presidential chair. He made frequent contributions to the Society's Proceedings, but these he was usually reluctant to publish, although in the last number of the *Transactions* there appeared a valuable account of his work on the eradication of bracken. This paper, "Notes on the Effect of Cutting Bracken," proved to be his last contribution.

But Smith's influence as a botanist, as an investigator, and as a teacher was known and felt far beyond our own immediate circle. He had already done pioneer work in botanical survey before settling in Edinburgh. In this he followed the lines adopted by his brother Robert; and another has written of him that "if he had not taken up his brother's work where it was interrupted by death, and had not inspired his pupils in Yorkshire—Moss, Rankin, and Woodhead—to extend and develop it, the British Vegetation Committee, out of which grew the British Ecological Society, would never have been founded; and though by this time, doubtless, a good deal of ecological work would have been done in Britain, it would certainly have taken different lines." No one who knew W. G. Smith would ever have gathered from him that he had thus given so much impetus to the study of plant ecology in this country, and had played so conspicuous a part in guiding its progress through a quarter of a century. He was too modest a man to claim credit for himself.

With the main outline of Dr. Smith's life most of us are familiar. He was born in Dundee on the 20th March 1866.

At the age of eighteen he entered the University College there and attended the usual classes for graduation in Science, gaining prizes in Physics, Chemistry, and Zoology. In 1890 he graduated B.Sc., taking Botany and Zoology as the final subjects of examination. After a short term of teaching as assistant science master at the Morgan Academy, Dundee, he proceeded to Edinburgh to undertake post-graduate work in Botany under the late Sir Isaac Bayley Balfour, in whose classes he also acted as demonstrator. His interest in agriculture is evinced in his attendance at the University class in this subject during his sojourn in Edinburgh. In 1892 he left Edinburgh to undertake the duties of lecturer in agriculture under the Forfarshire County Council. This appointment gave him opportunity to study farming practice in his native county, and it was during this time that he became interested in the diseases of plants. Thereafter followed a period of study and research at the University of Munich under Professors Hartig and Tubeuf, and in the year 1894 he graduated Ph.D. Munich, his thesis being entitled "*Untersuchung der Morphologie und Anatomie der durch Exoascen verursachten Spross- und Blatt-Deformationen.*" This thesis was subsequently translated into Italian. A further outcome of his sojourn in Munich was his translation of Tubeuf's "*Pflanzenkrankheiten,*" which was published in 1897 as "*Diseases of Plants induced by Cryptogamic Parasites.*"

On his return from Munich in 1891 Smith was appointed lecturer in plant physiology in the University of Edinburgh, a lectureship established in that year, and his was the first appointment. This post he held for three years, and in 1897 he became a member of the staff of the Biological Department of the University of Leeds, holding the position of lecturer in Agricultural Botany and assistant lecturer in Botany.

While the early period of Smith's career was marked by his interest in plant disease—an interest which remained with him to the end—a new and refreshing outlook developed before he had been long in Leeds. Both he and his brother Robert had come under the influence of Prof. Geddes at Dundee, and both had been impressed with the value of local surveys. After a further course of study under Prof. Flahault at Montpellier, Robert led the way in this country in what was real pioneer work in the study and survey of Scottish vegetation.

His first papers dealt with the vegetation of the Tay basin. The early and unexpected death of Robert Smith in 1900 was a severe blow to plant ecology in Britain, then in its infancy, but William was quick to realise the importance of the new line of study, and entered into it with characteristic energy and zeal. He continued his brother's work in the botanical survey of Scotland—accounts of the Edinburgh and North Perthshire districts had already appeared in the "Scottish Geographical Magazine" for 1900—and in 1904 he published in the same journal an account of the vegetation of Forfar and Fife. These studies were more than a mere mapping of the vegetation. They emphasised the relationships of plant communities not only among themselves but also to economic needs. Moreover, they aroused in the field botanist a new interest in the study of local floras. This was soon felt in the centre where Smith was teaching. With the assistance of his pupils, Moss and Rankin, at Leeds he undertook the botanical survey of Yorkshire, and in 1903 there were published the first two vegetation maps in England, dealing with the geographical distribution of vegetation in Yorkshire.

From these beginnings there was soon felt the need of some central organising body for the systematic study of British vegetation, and due largely to Dr. Smith's foresight and initiative there was established "A Central Committee for the Study and Survey of British Vegetation," afterwards known as the "British Vegetation Committee." Of this he was secretary, and did much in inspiring the earlier work in plant ecology in this country. When the British Ecological Society was founded in 1913 he was unanimously elected an Honorary Life Member, and he was President of the Society for the years 1918 and 1919. To the first number of the "Journal of Ecology," published in March 1913, he contributed an important paper dealing with Raunkiaer's "Life-Forms" and Statistical Methods, thus bringing to the notice of ecologists the value of studying the "biological type" to which species belong. He himself applied the method with valuable results in his studies on the composition of grasslands.

In 1908 Smith returned to Edinburgh as lecturer in Biology at the Edinburgh and East of Scotland College of Agriculture. His intimate knowledge of ecological work and methods was soon turned towards the solution of outstanding agricultural

problems in Scotland, especially the utilisation and improvement of hill pasture. He made plans for a complete agricultural survey of the Southern Uplands, and a good deal of ground had been covered when the work was interrupted by the War. The account published in the "Journal of Ecology," March 1918, dealing with the distribution of *Nardus stricta* in relation to peat, illustrates clearly the scheme he had in view, and shows also how closely he kept in mind the economic bearing of the work. He never separated practice and theory, and he will always rank among the first in this country to realise the importance of applied plant ecology.

The acquisition by the Edinburgh College of Agriculture of Boghall Farm gave Dr. Smith experimental ground conveniently situated for the further pursuit of his investigations on hill pasture. He had many problems in hand, and the farm had a great attraction for him. Every morning he looked out to see if it was a "farm day" or a "college day," and he dressed accordingly! In addition to local problems he was also engaged on investigations in connection with the School of Animal Nutrition at Cambridge, especially in the nutritive value of pastures.

Dr. Smith retired from teaching duties in 1926, when he was appointed Advisory Officer in Agricultural Botany to the Board of Agriculture for Scotland. No one was better fitted for the post, for on matters concerning agricultural botany in Scotland no one had a wider or more varied experience. But by many he will be remembered best as a teacher who had his own ways of teaching. Both in the laboratory and in the field he gained the confidence and affection of his students, attracted by his impressive personality and mastery of his subject.

J. R. MATTHEWS.

ROBERT COCKBURN MILLAR.

1853-1929.

It was with feelings of deep regret that the Botanical Society learnt of the death of Mr. R. C. Millar, C.A., which took place at his home in Edinburgh on the 19th April 1929. For many years he was one of the best known and most highly esteemed of Edinburgh chartered accountants, and although his professional work claimed a great part of his time, he

nevertheless found opportunities to cultivate wide tastes in Literature and Science. He had a genuine interest in Botany, Zoology, and Geology; was a member of a number of Scientific and Natural History Societies, and did much to aid their advancement and arouse the interest of others. We of the Botanical Society feel that we have lost a good friend, a very helpful member and office-bearer.

Among the last times I saw Mr. Millar was at the Glasgow meeting of the British Association for the Advancement of Science, which he was attending as a delegate of a number of Edinburgh societies. It was on this occasion he told me something of his early schooldays, speaking of the late sixties of last century. His own school was the Royal High, and among subjects of instruction which made a special appeal to him was Natural History, of which a good deal was taught. On leaving school he attended classes at the Watt Institution—now the Heriot-Watt College—and to his delight he carried away the prize in the class of Botany. In other channels, however, Mr. Millar was to find his lifework. As a young man he was apprenticed to the late Mr. Charles Murray Barstow, one of the original members of the Edinburgh Society of Accountants. Subsequently he joined Mr. Barstow in partnership, and by his own merit and ability he rapidly attracted a large volume of business, and soon the firm of Barstow & Millar stood in the front rank of the profession. Of Mr. Millar's own work only this need be said, and I quote from another who has already paid him tribute: "To him quality was everything." Not only did Mr. Millar have a brilliant career as a chartered accountant, he had also a large share in everything pertaining to the work of the Society of Accountants. "Few members did more for its advancement and prestige than he." And in due course the Edinburgh Society honoured him by electing him President, a post he held from 1910 to 1913. He was also a past Honorary President of the Chartered Accountants Students' Society, in which he always took a lively interest. He was a frequent contributor to the "Accountants' Magazine" and author of the "Accountants' Handbook." For fifty-two years he was a member of the Edinburgh Chamber of Commerce, and acted as Chairman for the year 1907-1908. He was one of the Trustees of the Edinburgh Savings Bank and a director on other

companies, and in these offices his wide knowledge of finance was of the greatest service.

In the sphere of Education, especially business training, Mr. Millar's contribution will remain outstanding. He undertook the organisation of the business side of the Heriot-Watt College at the time when Sir Francis Grant Ogilvie was appointed Principal, and for many years he gave lectures on the "organisation and technique of industry and commerce." He was, in fact, the first Lecturer on the Practice of Commerce at the Heriot-Watt College, and this, like much of his work, was a labour of love. One of his old pupils now carries on the work as Professor of Commerce in the University of Edinburgh.

Mr. Millar's connection with our own Society is a long one—he was elected a Fellow in 1890. Two years later, when the Society required the assistance of an auditor, Mr. Millar's services were secured. From that time until last year he has audited our accounts annually, and the Society remembers with gratitude the assistance so freely and so willingly given. He was a frequent attender at our meetings, and many will recall his bright and cheery presence. Those who knew him found always the same kind and friendly welcome, typical of the true nature of the man.

J. R. MATTHEWS.

ARTHUR BENNETT.

1843–1929.

When the late Professor Trail commenced the publication of "Topographical Botany of Scotland" in the "Annals of Scottish Natural History," 1898, he wrote that "the thanks of all interested in the Scottish flora are due in a very special degree to Mr. A. Bennett for the unwearied assistance he has given to local botanists in determining the critical species of their districts, and for his 'Additional Records of Scottish Plants,' in which he has brought together and put within our reach, year by year, the information scattered through our own journal, the 'Journal of Botany,' the publications of societies, and occasional floras in book form. The value of the 'Records' is most appreciated by those that know them best." Thirty years have passed and the same tribute may well be penned again. By the death of Arthur Bennett, not only Scottish

Botany but British Botany has lost an ardent worker, and one who never became weary in helping others. Something of his life-story and of his work has been told by Dr. G. Claridge Druce and Mr. C. E. Salmon in a recent number of the "*Journal of Botany*," but it is fitting that our own *Transactions* should bear testimony to the worth of one of our oldest Associates and one of the most regular contributors to our pages.

Arthur Bennett was born at Croydon on 19th June 1843, the son of a builder and house decorator. On leaving school he entered his father's business, to which he eventually succeeded, and which he carried on until the time of his death on 2nd May 1929. For over fifty years he devoted much time and energy to the elucidation of many of the critical genera in our native flora, while the topographical distribution of plants was one of his great interests. He had a very wide circle of correspondents, from whom thousands of specimens poured in upon him, involving an enormous amount of labour in their sifting; but he never failed to reply to a query, and he really enjoyed working out a difficult problem to help a fellow-worker. He had a wonderful capacity for making notes, as his letters abundantly show, and it is not surprising that his published notes and papers run into hundreds. What is surprising is that a business man with restricted space, time, and library should have accomplished so much. For Bennett was not only one of the best all-round amateur botanists of his day, he was a recognised expert on certain groups of plants—especially aquatics—and an authority on the genus *Potamogeton*. He was responsible for the completion of Fryer's "*Potamogetons of the British Isles*," and the authorities at Kew and at the British Museum entrusted him with the naming of pondweeds from all parts of the world.

In Topographical Botany he continued the work of H. C. Watson, and in 1905 published a supplement to the second edition of Watson's work; while in the "*Journal of Botany*" for May of this year there appeared the first instalment of a second supplement, in the preparation of which he had the assistance of Mr. C. E. Salmon and myself. He was especially interested in the botany of East Anglia, yet he did not suffer from any narrow provincialism. If the gaps in Watson's "*Topographical Botany*" were to be filled, he recognised the need for steady systematic work chiefly in many of the northern

counties. Thus he commenced in 1886 the publication in the "Scottish Naturalist" of "Additional Records of Scottish Plants," and these continued yearly until 1891, subsequently finding a place in the "Annals of Scottish Natural History," almost without a break until 1905. He was much interested in the flora of Caithness, Sutherland, and the Outer Hebrides, and contributions towards a "Flora of Caithness" appeared at regular intervals in the "Scottish Naturalist," the "Annals of Scottish Natural History," and in our own *Transactions* from 1888 until 1928. This interest in the flora of the north of Scotland was part of Bennett's love for the flora of Scandinavia, Iceland, and the Faroes. That the floristic affinities of these areas attracted his attention early appears from his compilation of a list of plants ("Scottish Naturalist," 1885) occurring in Iceland and the Faroe Islands but not known as British. It is interesting to note the inclusion of *Arabis alpina* Linn. in this list, which he thought should occur in Scotland judging from its general geographical distribution—an opinion which was proved to be correct by its discovery in Skye only two years later. Again, *Carex microglochin* Wabl., which also appears in the list and which "might well be passed over as *pauciflora*," was added to the Scottish flora as recently as 1923.

It is impossible in a brief notice to deal fully with Bennett's contributions to British field botany. In the "Journal of Botany" alone, from the appearance of his first note in 1878, "no fewer than two hundred and forty-three notes, papers, and reviews have appeared in its pages." To Scottish publications he was likewise a liberal contributor, and in our own *Transactions* some forty papers have come from his pen. He was elected an Associate of our Society in 1886, a Fellow of the Linnean Society in 1881, retiring in 1905, but he was made an Associate of that Society in 1910. As Mr. Salmon has written: "Not only has British Botany and the investigation of *Potamogeton* throughout the world suffered a severe loss by his death, but many of us are feeling how much we miss an old and valued friend."

J. R. MATTHEWS.

DAVID PAUL.
1845-1929.

The death of the Very Rev. Dr. Paul, which took place at his residence in Edinburgh on 12th July 1929, removes from the roll of our Society a man of rare and varied gifts, a distinguished minister of the Church of Scotland, and a great lover of Nature. For long he was in our midst, a familiar figure at our meetings, and there are many who will miss his warm and genial welcome and the charm of his gracious personality.

Dr. Paul was a son, a grandson, and, through his grandmother, a great-grandson of the Manse. His father, Dr. William Paul, an eminent Hebrew scholar, was minister of the parish of Banchory-Devenick, and in the parish manse David Paul was born on 28th August 1845. His early education was gained at Banchory, and was continued at the University of Aberdeen, which he entered as first bursar of the year at the age of seventeen. His academic career was one of great distinction. He was prizeman in several classes, and graduated in Arts, with first-class honours in Classics and second-class honours in Mental Philosophy. He was awarded the Town Council Gold Medal as the most distinguished graduate of the year, and was elected Fullarton Scholar in Classics and Mental Philosophy. His course in Divinity was taken partly at Aberdeen and partly at Edinburgh.

In 1869, at the early age of twenty-three, Dr. Paul was ordained at Morebattle, and was translated to Roxburgh in 1876, where he ministered for twenty years. There he took an active share in the public work of the community, acting as chairman of the School Board, chairman of the Parish Council, and clerk to the Presbytery of Kelso. In 1896 he was called to the Robertson Memorial (Grange) Church in Edinburgh, which charge he held until his resignation in 1919. "In each of his spheres of labour," says another, "he proved himself a model parish minister, attentive and devoted to all the interests of his people, while taking a weighty share in the wider work of the Church." And it was no small burden that Dr. Paul undertook to carry in the larger administrative work of the Church. A vast amount of committee work, dealing

with different departments of the Church's activities, was carried on for many years, added to which was his appointment in 1909 as Depute-Clerk of the General Assembly, to be followed three years later by his appointment as Principal Clerk, an office he held until 1926. The highest honour the Church can bestow—the Moderatorship—was awarded in 1915. To quote from an appreciation appearing in the "Scotsman" at the time of his death: "The distinction of his career had made the honour inevitable, and thus its bestowal was received with warm and general assent. In the discharge of the duties of the high office he bore himself with that dignity and gracious courtesy which were so marked a feature of his personality, and he guided the deliberations of the General Assembly with a clear and sound judgment."

As the Church has lost a great leader, so botanical science has lost a loyal and devoted student. Though some of the more modern cults of Botany may not have made a very strong appeal, yet the older and perhaps more fundamental outlook of "knowing one's plants" was keenly developed, and this Society, and Scottish Botany in general, owes much to his enthusiastic pursuit of systematic work in the field. A wide knowledge of our native flowering plants was added to an intimate acquaintance with the cryptogams. He knew the larger British fungi well, and ferns were a constant source of study and enjoyment. Nor was his Botany restricted to narrow bounds. He was a great traveller, and more than one voyage to distant lands was undertaken in search of a fuller knowledge of the plant world. In 1889 he spent five weeks in British Guiana, and our *Transactions* for 1891 are enriched by a vivid description of the vegetation of that area. His object in going, he tells us, was to see tropical rain forest. "To see Palms growing in perfection had been a long]cherished dream, and it was now realised to the full."

Dr. Paul's connection with the Botanical Society dates from 1883, when he was elected a Fellow. He was President for the Sessions 1899 1901, and in 1906 he was elected Foreign Secretary, continuing in this office until the time of his death. His two presidential addresses, "On the Ferns, especially the Filmy Ferns, of Jamaica," and "The European Species of the Genus *Primula*," illustrate his scope of subject and width of outlook. The first is presented in that fluent style which is

characteristic of much of his writing; the second is more analytical, denoting the exact and critical mind. A further communication in 1911, unfortunately never published, dealt with the Marattiaceae and Schizaeaceae, especially those native of Jamaica.

Despite these excursions into far fields, Dr. Paul's interest in British Botany never waned. He enjoyed nothing better than a day on the hills, and he would travel far to see a rare plant growing in its native place. Such outings were never forgotten, and they were often the occasion for anecdote and reminiscence. Of the Scottish Alpine Botanical Club he was at different times Secretary and Treasurer and President. The reports of excursions which came from his pen are vivid accounts of days spent in exploring some of the remoter corners of Scotland. To those of us who are younger, who may be fired with a like enthusiasm to see our native flora, there is something to be gained by a reading of these stories as told by Dr. Paul. His was a real love of plant life, and he could tolerate no wanton destruction. Writing in 1901 of a search made for the Killarney Fern, which was at one time found in many localities near Lough Cruttia, but now nearly, if not quite exterminated by collectors, he says: "It is sad to think that so interesting a plant should be doomed to extinction to satisfy an ignorant and stupid cupidity."

Dr. Paul's interest in flowering plants and ferns was more than equalled by his interest in fungi, particularly the Hymenomycetes. For many years he was a member of the Cryptogamic Society of Scotland, and was President in 1922. He was a member also of the British Mycological Society, and in recognition of his work and the encouragement he had given to the study of fungi, he was elected President in 1918. His presidential address to the Mycological Society, published in 1920, deals with the "Earlier Study of Fungi in Britain," and reveals at once not only his knowledge of the larger fungi, but also the literary charm with which he could adorn a scientific subject.

As the Church had honoured Dr. Paul, so also the Universities and Scientific Societies. In 1894 his Alma Mater recognised his classical and scientific attainments by conferring upon him the degree of LL.D., while the University of Edinburgh conferred the degree of D.D. in 1915. He was elected a Fellow of

the Linnean Society in 1926. Another and somewhat different honour, not unconnected with our own Society, came to him in 1923, when there was published the description of a *Primula* named in his honour. It is peculiarly fitting that the name of one who has done so much for our Society, who himself was an enthusiastic student of the European species of *Primula*, should be thus commemorated. Those who were present at the meeting when *Primula Pauliana*, W. W. Sm., was exhibited and described cannot but remember the beauty and appeal of Dr. Paul's words as he stood, in the fulness of his years, acknowledging the tribute which had been made to one of Nature's most devoted sons.

J. R. MATTHEWS.

TRANSACTIONS
OF THE
BOTANICAL SOCIETY OF EDINBURGH

SESSION XCIV

GLEN AFFRIC. By ROBERT MOYES ADAM.
(With Pl. XIV.)

(Read 20th February 1930.)

The movement set afoot to establish in Scotland a National Park has brought forward many places and scenes as favourable sites. If the main object of the park be to afford recreative facilities, it is desirable to have the place readily accessible to the masses. Should a National Domain be selected to form a "Reserve" open to the public yet with protection to fauna and flora as its main concern, remoteness might be considered an advantage.

It would be well to have in the site a landscape which will furnish the greatest topographical variety, with water and tracts of highly elevated ground intersected by valleys holding natural woodlands, features which in the fullest measure are characteristic of Scotland, and able to provide an environment for her indigenous plants and animals.

Glen Affric appears to fulfil these requirements, and offers an attractive site. Situated in the heart of Inverness-shire, Affric is the southernmost of three parallel valleys which run slightly south-west and west towards the north-east, and drain their waters respectively into Strath Glass, and ultimately unite to reach the Beaulf Firth as the river bearing

that name. Glens Cannich and Strathfarrar, the other glens, have considerable charm, and have much in common with Glen Affric; and were the territory embraced by these three glens chosen as a "park" Scottish naturalists would have reason to rejoice.

Glen Affric perhaps ranks first in point of interest. Entrance to the glen is gained at Fasnakyle through a deep defile—the "Chisholm's Pass," a scene that can have few rivals in Scotland for rugged grandeur—where light and airy birch woods clothe the craggy slopes on all sides except on the south, and there a remnant of Scots pine forest introduces a sombre tone. Far beneath the road ascending the pass the River Affric tumbles restlessly over a rocky bed in a gorge flanked by precipitous sides.

Beyond the defile the valley widens, and thereafter for about three miles birch and pine intermingle. Among their number some hoary giant pines stand with stems exceeding 12 feet in girth. On the skyline rises the imposing summit of Sgurr na Lapaich, over 3400 feet—a feature which gives a Swiss touch to the landscape. Loch Beinn a' Mheadhoin is the first of a chain of lochs which lie in the glen, and are linked by the Affric—in character reminiscent of a scene in the backwoods of Canada, the big pines coming right down to the water's edge.

The loch extends for three miles, and is of the highland type—no marginal vegetation, but in places fringed by white sand shores. Westwards a short deep channel connects with a small loch—Loch an Laghair, "the loch of the shoe." This in turn forms a further narrow channel, which after rapids and broken water becomes the long sinuous eastern extremity of Loch Affric itself.

The setting of this loch is unique and is the most picturesque of the series, and unsurpassed by any similar scene in Scotland. The loch measures over four miles in length, and big hills rise steeply from the north and south shores. Mam Sodhail, over 3800 feet, towers above all to the north, and forms the central peak of the big group of summits which separate Glen Affric from Glen Cannich.

On the slopes which descend on the south shores of all the lochs a remarkable remnant of old Caledonian Forest pines still flourish, but on the north slopes the forest is represented



Loch Affric from the east

by isolated trees. Tradition has it that this part was fired during some ancient clan feud, and to-day confirms the tale in the charred stumps that appear in places on the hillside. At no point does forest rise above 1600 feet, but in peat holes above 2000 feet the skeletons of former trees are frequently met with.

Glen Affric extends beyond the loch and becomes bare. The forest ceases and green slopes take its place—this is the region of high rainfall. The mountain panorama from this point is impressive—the jagged peaks of the Kintail hills, with alpine effect, occupy the western horizon. The farthest reach of the glen is but a few miles from the western sea and terminates at the watershed, a glen that covers nearly twenty-five miles from end to end.

For the naturalist the glen has unique interests. The flora is attractive, the region having suffered slight interference from man; indeed, history shows that during the last two centuries the glen was used more for hunting than for crofting.

The pine forest is the outstanding feature in the glen, and provides a rare example of the real old Caledonian Forest. The possession of such a tract is of the highest importance and will present to the botanist and zoologist a storehouse for study. The valley flora is characteristic of the highland districts, where few of the plant immigrants associated with cultivation are found. The mountain regions have a poorer representation of arctic alpine species than in the rich districts of Central Perth and Forfar, but among their number are a few absent from the latter.

For fauna the whole presents a natural sanctuary where even at present a remarkable host of animals, typical of Scottish wild life, live with little interference.

The Glen indeed is a bit of unspoiled Scotland, and in any National Park project could conserve in their wild state a truly representative group of Scotland's animals and plants, while preserving in all its glory one of her most beautiful glens.

A LIST OF SCOTTISH PANSIES.
By ERIC DRABBLE, D.Sc., F.L.S.

(Read 20th March 1930.)

During the past twenty years many pansies from various parts of Scotland have been sent to me for examination and identification and it has been suggested that the results of my work are of sufficient interest to justify the publication of a list of some of the determinations.

For material I am particularly grateful to the late Rev. E. S. Marshall, who often visited Perthshire and other parts of the country and was in the habit of sending me very fine representatives of his gatherings.

To Mr. W. H. Beeby, Dr. G. C. Druce, Miss I. M. Hayward, Colonel H. Halcro Johnston and Professor J. R. Matthews I owe a debt of thanks for much interesting material; I have also named for Mrs. M. Corstorphine a very long series of gatherings from Forfarshire. The sheets in the Herbaria at the British Museum and at Kew have been examined.

It must clearly be understood that the naming of the plants listed below is entirely my own work. The name of the collector has been given in brackets where a note of this has accompanied the specimen.

The gatherings range widely over Scotland, but Clackmannan, Dumbarton, Linlithgow and Peebles are still without records.

DUMFRIESSHIRE (72).

V. segetalis Jord. - Dumfries (Herb. H. E. Wilkinson).

V. ruralis Jord. - Moffat (S. A. Naylor).

V. lutea Huds. - Moffat (S. A. Naylor); Wanlockhead, Sanquhar.

KIRKCUDBRIGHTSHIRE (73).

V. segetalis Jord. - Gatehouse (D. Oliver).

WIGTOWNSHIRE (74).

V. segetalis Jord. - Drummore, Wigtown.

V. lutea Huds. - Glen Cree.

AYRSHIRE (75).

- V. lutea* Huds. f. *Pesneawi* (*V. Pesneawi* Lloyd et Foucaud).
—Stevenston, and between Troon and Dundonald
(R. Mackechnie).

RENFREWSHIRE (76).

- V. segetalis* Jord.—Loganswell (R. Mackechnie).
V. variata Jord.—Bute (J. D. Hooker, 1867).

LANARKSHIRE (77).

- V. lutea* Huds.—Cathkin Braes (R. M'Kay); Glasgow.
V. lutea Huds. f. *amoena* Henslow. - Cathkin Braes (R.
M'Kay); Strathaven (H. E. Fox).

SELKIRKSHIRE (79).

- V. segetalis* Jord.—Galashiels, Selkirk (I. M. Hayward).
V. Déséglisei Jord. Galashiels (I. M. Hayward).
V. contempti Jord.—Selkirk (G. C. Druce).
V. Lloydii Jord. -Galashiels (I. M. Hayward).
V. Lejeunei Jord. -Selkirk.
V. variata Jord. var. *sulphurea* Drabble. —Lindean Pebbles,
Selkirk (I. M. Hayward).
V. alpestris Jord. -Galashiels (I. M. Hayward).
V. monticola Jord. Lindean Pebbles, Tweedside, Galashiels
(I. M. Hayward).
V. lutea Huds.—Bowhill, Faldonside (E. S. Marshall);
Clovenfords, Ettrick Bridge near Selkirk (I. M. Hayward).

ROXBURGHSHIRE (80).

- V. segetalis* Jord.—Lindean (I. M. Hayward); Melrose.
V. Déséglisei Jord. -Kelso.
V. monticola Jord. Abbotsford, Lower Faldonside, Smail-
holm (I. M. Hayward).
V. alpestris Jord. Abbotsford (W. A. Sledge).
V. lepidu Jord. Yetholm (I. M. Hayward).
V. lutea Huds. -Abbotsford (1870).

BERWICKSHIRE (81).

- V. Déséglisei* Jord.—Berwick.
V. ruralis Jord.—Berwick.
V. lutea Huds.—Yarrow Haugh.
V. lutea Huds. f. *calaminaria* (Lej.).—Lauder (I. M. Hay-
ward).

HADDINGTONSHIRE (82).

V. ruralis Jord.—North Berwick Law.

EDINBURGH (83).

V. arvensis Jord.—Swanston near Edinburgh (1857).

V. lutea Huds.—Dalmahoy (G. Lloyd, 1825): Blackford Hill near Edinburgh, Pentland Hills

FIFESHIRE (85 in part).

V. segetalis Jord. f. *obtusifolia* (Jord.).—Kilmeny.

V. Déséglisei Jord.—Tayport (C. H. Murray).

V. Lloydii Jord.—Cleish.

V. lutea Huds.—South Lethane (J. H. Balfour, 1825); Dunearn Hill.

V. lutea Huds. f. *Curtisii* (Forster).—Tayport (C. H. Murray)

KINROSS-SHIRE (85 in part).

V. lutea Huds.—Ochil Hills (J. R. Matthews).

STIRLINGSHIRE (86).

V. lutea Huds.—Callander (Miss Prescott).

PERTHSHIRE (87, 88, 89).

V. derelicta Jord.—Lochay, Killin.

V. variata Jord.—Menteith (E. S. Todd).

V. lepida Jord.—Glen Lochan (R. J. Burdon); Loch Rannoch (A. Wilson and J. A. Wheldon); Glen Lochay, Glen Spean.

V. lutea Huds.—Glen Isla, Loch Rannoch, Glen Turrit, Breadalbane, Fortingal, Glen Ardlie, Craig Caillaich, Glen Lyon, Glen Farg (Ochils), Glen Carness, etc.

V. lutea Huds. f. *amoena* Henslow.—Loch Tummel, Ben Lawers, Killin, Sow of Athol, Dalnaspidal, Glen Isla, Glen Shee, etc.

— f. *insignis* (subvar. *insignis* E. G. Baker).—Craig Caillaich (J. Helsby).

V. lutea Huds. f. *Murrayi* Drabble.—Bank of the Spey.

V. lutea Huds. f. *sudetica* Willd.—Killin (P. Ewing).

(*V. lutea* and f. *amoena* have been sent to me from Perthshire by many collectors, amongst whom may be mentioned G. C. Druce, E. S. Marshall, J. R. Matthews, C. H. Murray and C. E. Salmon.)

ANGUS (FORFARSHIRE) (90).

- V. agrestis* Jord.—Forfar (G. C. Druce); Barry, Brechin, Bridge of Dun, Clova (Mrs. Corstorphine).
- V. segetalis* Jord.—Clova (G. C. Druce); Lunan (Mrs. Corstorphine).
- V. segetalis* Jord. f. *obtusifolia* (Jord.).—Monifieth (E. S. Todd); Arbroath (Mrs. Corstorphine).
- V. Déséglisei* Jord.—Auldbar, Barry, Brechin, Bridge of Dun, East Haven, Lunan Bay (Mrs. Corstorphine).
- V. derelicta* Jord. —Dundee, Invergowrie (C. H. Murray); Arbroath, Auldbar (Mrs. Corstorphine).
- V. arvensis* Jord.—Dundee (C. H. Murray); Clova (W. A. Sledge); Arbroath, Auldbar (Mrs. Corstorphine).
- V. ruralis* Jord.—Arbroath, Barry, Lunan Bay, Montrose (Mrs. Corstorphine).
- V. latifolia* Drabble.—Auldbar (Mrs. Corstorphine).
- V. Lloydii* Jord. Balgavies (G. C. Druce); Bridge of Dun, Forfar (Mrs. Corstorphine).
- V. Lejeunei* Jord. —Balgavies (G. C. Druce); Arbroath (Mrs. Corstorphine).
- V. variata* Jord. —Arbroath, Carmylie Moor, Clocksbriggs, Clova, Colliston, Lunan Bay, Red Head, Rossie Moor (Mrs. Corstorphine).
- V. variata* Jord. var. *sulphurea* Drabble.—Lunan Bay, St. Vigeans (Mrs. Corstorphine).
- V. monticola* Jord. Clova (Mrs. Corstorphine).
- V. alpestris* Jord. —Clova (Mrs. Corstorphine).
- V. lepida* Jord. —Dunninald, Forfar, Lunan Bay (G. C. Druce); Barry Links (R. Mackenzie); Monifieth (E. S. Todd); Dicty Moor, Lethane, Montrose, Red Head, Rossie Moor (Mrs. Corstorphine).
- V. lutea* Huds. Canlochan (H. C. Watson); Clova (A. Croall, 1840); Deer Forest, Forfar (W. Gardiner, 1843); Braemar, Carmylie, Dundee, Glen Doll, Lorn Hill.
- V. lutea* Huds. f. *amoena* Henslow.—Canlochan (H. C. Watson); Clova (A. Croall); Arbroath (Mrs. Corstorphine); Braemar.
- V. lutea* Huds. f. *Curtisii* (Forster).—Auldbar, Lunan Bay (Mrs. Corstorphine).

KINCARDINESHIRE (91).

- V. agrestis* Jord.—Bervie (C. Bailey).
V. segetalis Jord. f. *obtusifolia* (Jord.).—Banchory (G. C. Druce).
V. Déséglisei Jord. f. *subtilis* (Jord.). Bervie (C. Bailey); Banchory (G. C. Druce).
V. ruralis Jord.—Bervie (C. Bailey).
V. variata Jord.—Stonehaven (C. Bailey).
V. lepida Jord. —Banchory, St. Cyrus (G. C. Druce); Cross-michael (H. E. Fox); Stonehaven.

ABERDEENSHIRE (92, 93).

- V. derelicta* Jord.—Glen Muick (C. H. Murray).
V. Lejeunei Jord. —Alford (G. C. Druce).
V. variata Jord.—Kincardine (Aberdeenshire).
V. lepida Jord.—Ballater, Braemar (G. C. Druce); Glen Muick (C. H. Murray).
V. lutea Huds. —Craig Kynoch (W. Gardiner, 1845); Glen Muick, Kincardine O'Neil (C. H. Murray); Braemar.
V. lutea Huds. f. *amoena* Henslow. Glen Muick, Kincardine O'Neil (C. H. Murray).
V. lutea Huds. f. *sudetica* (Willd.) — Ballater (H. H., 1847).

BANFFSHIRE (94).

- V. derelicta* Jord.—Inchrory, Glen Avon.
V. lutea Huds.—Tomintoul.

MORAYSHIRE (ELGIN) (95).

- V. segetalis* Jord. f. *obtusifolia* Jord. Longmorn (K. D. Little).
V. variata Jord. Longmorn (K. D. Little).
V. lepida Jord. Forres (C. Bailey).
V. lutea Huds. —Dava.

INVERNESS-SHIRE (96, 97).

- V. lepida* Jord.—Glen Spean (E. S. Marshall).
V. lutea Huds. Aviemore (C. E. Salmon); Kiucrraig (A. Somerville); Dalwhinnie, Fort Augustus, Glen Spean.
V. lutea Huds. f. *amoena* Henslow.—Arderikie Forest (W. A. Shoolbred).
V. lutea Huds. f. *Pesneau* (Lloyd and Foucaud).—Glen Beg (A. Somerville).

ARGYLLSHIRE (98, 101).

V. Lejeunei Jord.—Dalmally (E. S. Marshall).

V. lepida Jord.—Dalmally (E. S. Marshall).

V. lutea Huds.—Benderloch.

V. lutea Huds. f. *Curtisii* Forster.—Ardnamurchan and Island of Coll (S. M. Macvicar) : Ardlamont.

ARRAN (100).

V. agrestis Jord.—Arran (G. C. Druce).

V. segetalis Jord. f. *obtusifolia* (Jord.).—Brodict (W. G. Travis).

V. lutea Huds. f. *amoena* Henslow.—Machrie Bay (H. W. Daltry).

V. lutea Huds. f. *Curtisii* (Forster).—Brodict, Dromodune (W. G. Travis).

ROSS-SHIRE AND CROMARTY (105, 106).

V. segetalis Jord. Strathcarron.

V. variata Jord. Big Sand, Dingwall, Ullapool (G. C. Druce).

V. lepida Jord.—Achilty (E. S. Marshall and W. E. Shoolbred) ; Big Sand, Dundonnell (G. C. Druce).

V. lutea Huds. f. *Curtisii* (Forster). Loch Carron.

SUTHERLAND (107, 108).

V. agrestis Jord. Tongue (E. S. Marshall).

V. segetalis Jord. Dornoch (E. S. Standen) ; Golspie.

V. derelicta Jord. Melvich (E. S. Marshall).

V. Lejeunei Jord. Melvich (E. S. Marshall, G. C. Druce).

V. orcadensis Drabble. Melvich (E. S. Marshall).

V. variata Jord.—Invershin (G. C. Druce) ; Tongue (E. S. Marshall).

V. lepida Jord. Altnaharra (G. C. Druce).

V. lutea Huds. f. *amoena* Henslow. Durness (H. E. Fox) ; Inchnadamph.

V. lutea Huds. f. *Curtisii* (Forster).—Far-out Head (H. E. Fox) ; Golspie.

CAITHNESS (109).

V. Lejeunei Jord. Thurso (G. C. Druce).

V. orcadensis Drabble. Reay (W. F. Millar) ; Wick (E. S. Marshall).

V. variata Jord.—Island of Stroma (A. M. Geldart); Wick (E. S. Marshall).

V. lepida (Jord.).—Thurso, Wick (H. E. Fox).

V. lutea f. *Curtisii* (Forster).—Reay Links (W. F. Millar); Dunnet Links (C. E. Salmon); Sinclair Bay (J. Grant); Keiss Links.

OUTER HEBRIDES (110).

V. lutea Huds. — Benbecula and Kirkibost Island, N. Uist (W. H. Beeby).

V. lutea Huds. f. *Curtisii* (Forster).—Barra and S. Uist (A. Somerville); Barve and Huishenish, Harris (G. C. Druce).

ORKNEY (111).

V. agrestis Jord.—Hurkigarth, Mainland (H. H. Johnston).

V. derelicta Jord.—Loch Skaill (W. A. Shoolbred); Birsay, Firth, Stromness (H. H. Johnston).

V. Lloydii Jord.—Birsay, Orphir (H. H. Johnston).

V. Lloydii Jord. var. *insignis* Drabble.—Hoy, Stromness (H. H. Johnston).

V. Lejeunei Jord.—Loch Skaill (W. A. Shoolbred); Birsay, Cairston, Firth, Stromness, South Ronaldshay (H. H. Johnston).

V. variata Jord. — Quoy's Hoy (G. C. Druce); Cava, Deerness, Evie, Egilsay, Fara, Flota, Graemsay, Rendall, Shapinsay, Stromness, Stronsay, Testaquoy, Viera (H. H. Johnston).

V. orcadensis Drabble. — Kirkwall (W. R. Linton); Stronsay (— Gibbs); Birsay, Deerness, Fara, Hurkigarth, Sandwick, Stronsay (H. H. Johnston).

V. lutea f. *Curtisii* (Forster) (including *Pesneauii*). — Banna Cross (Sanday), Evie, Saint Old, Stywick (Sanday) (H. H. Johnston).

SHETLAND (112).

V. derelicta Jord. — Dunrossness (W. H. Beeby).

V. Lejeunei Jord.—Fetlar (G. C. Druce).

V. orcadensis Drabble.—Baltasound, Sullom Voe (W. H. Beeby).

V. variata Jord. — Baliaster near Baltisound (W. H. Beeby); Barrafirth (Unst), Norwick (Unst) (G. C. Druce); Fetlar (H. H. Johnston).

V. lutea Huds.—Dalmahoy (Unst).

V. lutea Huds. f. *Curtisii* (Forster).—Fetlar (G. C. Druce).

(Many other records of pansies named by me from the Orkneys and Shetlands have been published by Colonel H. H. Johnston in the “Transactions of the Botanical Society of Edinburgh.”)

LEAF ANATOMY OF THE BRITISH HEATHS.

By MARGARET H. SMITH, B.Sc.

(Read 20th March 1930.)

This investigation of the British heaths was commenced with the object of determining the exact systematic position of the peculiar sport *Erica Crawfordii*. This heath was first found by Mr. F. C. Crawford, in 1901, during an excursion of the Scottish Alpine Botanical Club to Ireland, where it was growing on Craigga-More, near Roundstone, Galway, Connemara.

There has been much doubt in the past as to the systematic position of *Erica Crawfordii*. Neither Babington, Hooker, nor Hayward make any reference to this double variety. In Druce's British Plant List, 1928, it has been determined as a variety of *E. Tetralix*, but in the List of Trees and Shrubs grown in Kew Royal Botanic Garden it is recorded as a variety *flore pleno* of *Erica Mackayi*. Since Bentham and Hooker and Hayward regard *Erica Mackayi* itself as a variety of *Erica Tetralix*, *Erica Crawfordii* was classified by Professor Bayley Balfour in 1904, according to herbarium sheets, as *Erica Tetralix* var. *Mackayi*, forma *flore pleno*.

Thus it can be seen that the systematic position of *E. Crawfordii* involves the relations between *E. Tetralix* and *E. Mackayi*, since the latter has been variously placed. This has entailed an investigation for purposes of comparison into the three heaths mentioned, and also into certain other species allied to them. *E. Tetralix* and *E. Mackayi* come nearest to *E. Crawfordii* in systematic characters, the other species standing a good deal further away. The distinctions between *E. Mackayi* and *E. Tetralix* have been much discussed in the past. *E. Mackayi* was first found in Connemara, and Dr. Mackay, author of the Flora Hibernica, pointed out a resemblance to *E. ciliaris* in mode of growth and size. The identical heath was found in Truro, Cornwall, growing beside *E. ciliaris*. Hooker and Watson considered it to be a hybrid between *E. Tetralix* and *E. ciliaris*, because it seemed so completely intermediate in systematic characters between the two.

Consequently one would naturally expect to find *E. ciliaris* in Connemara. It has been found in Dorset, Cornwall, West France, Spain and Portugal, but never in Ireland.

Professor Macfarlane has already discussed the relations between *E. Mackayi* and *E. Tetralix*, and his argument appears in the "Transactions of the Botanical Society of Edinburgh." He and Sir J. Hooker came to the conclusion that *E. Mackayi* was not a hybrid but a well-marked variety or sub-species of *E. Tetralix*.

It seemed therefore that a more detailed examination of the leaf anatomy might serve not only to discriminate between *E. Tetralix* and *E. Mackayi*, but also solve the immediate problem of the relationship of *E. Crawfordii*.

In order to compare *E. Tetralix*, *E. Mackayi*, *E. Crawfordii*, and nearly allied species of heaths for their diagnostic characters, an analysis of each was made under two headings—(1) leaf characters. (2) leaf anatomy.

ERICA TETRALIX.

Leaf Characters. --Leaves petiolate 1 mm., linear-lanceolate $4\frac{1}{2}$ mm. \times $1\frac{1}{2}$ mm., margins much incurved, exposing one-third of the under surface.

Lamina and petiole pubescent, leaf margins bearing two to three rows of glandular hairs.

Anatomy. Upper epidermal cells small, tangentially elongated $36\mu \times 21.5\mu$ approx., strongly cuticularised 10μ in thickness.

Numerous simple unicellular hairs, either long with thin walls, or short with thicker walls.

Lower epidermal cells small, oblong, and less strongly cuticularised.

Stomata situated in the grooves of the rolled leaf, guard cells projecting above the level of the epidermis. Both glandular hairs, and simple hairs of two kinds, form a dense covering

Glandular hairs are either (1) those of an unusual knuckle-bone shape, stalk two-celled, with a multicellular glandular head occurring on the under side of the leaf; or (2) long rigid hairs with a multicellular stalk and glandular head occurring on the leaf margins. Simple hairs either (1) short, curved,

papillate, occurring in the grooves, four to six arching over the stoma; or (2) long, straight, papillate, occurring on the mid-rib.

In all species examined the mesophyll is differentiated into palisade tissue of long narrow cells, occupying approximately the upper half of the leaf, and spongy tissue of loosely arranged cells, irregular in shape and size.

The bundle is large and more or less circular in outline, surrounded by a stereome, which is more developed on the upper and under sides of the bundle. A layer of parenchyma intervenes between the stereome and the lower epidermis.

The xylem vessels are relatively few, and small, forming a cluster.

ERICA MACKAYI.

Leaf Characters.—Leaves petiolate $\frac{1}{2}$ mm., oblong 3 mm. \times $1\frac{1}{2}$ mm., margins revolute, exposing four-fifths of the under surface.

Lamina and petiole glabrous, except leaf margins which bear one row of large glandular hairs.

Anatomy.—Upper epidermal cells large, radially elongated 36μ \times 40μ approx., cuticularised 8μ in thickness. All the upper epidermal cells with rare exceptions show a clear transverse septum, dividing the cell into two approximately equal parts.

Lower epidermal cells small, oblong, and cuticularised. Guard cells of stomata project above the level of the epidermis.

Simple, short, curved, papillate hairs occur on under surface, two to four arching over the stoma. No hairs on mid-rib.

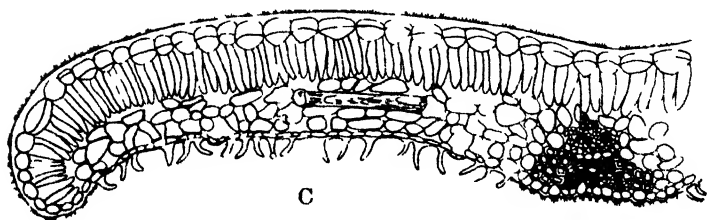
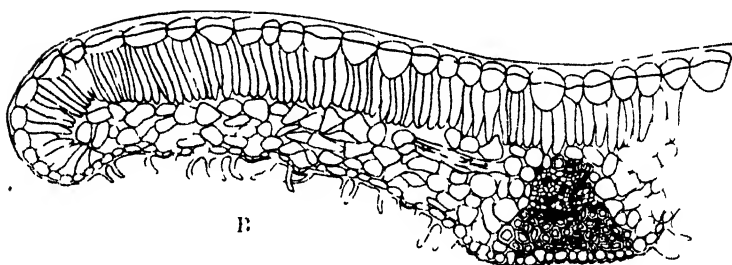
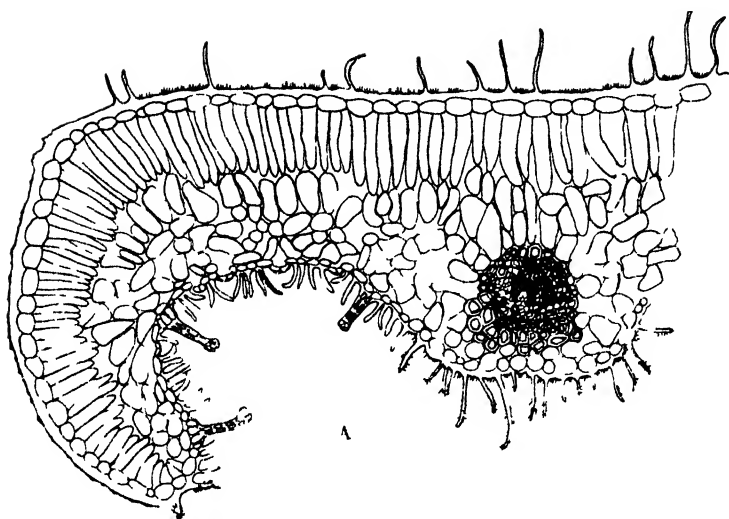
The bundle is large and triangular in outline, the base being parallel to the lower epidermis. The stereome consists of a small patch of cells on the upper side of the bundle, and a large patch below, extending to the epidermis.

Xylem vessels small, in groups of two to five.

ERICA CILIARIS.

Leaf Characters.—Leaves petiolate $\frac{1}{2}$ mm., ovate $3\frac{1}{2}$ mm. \times 2 mm., margins revolute, exposing seven-eighths of the under surface.

Lamina and petiole pubescent, leaf margins bearing many glandular hairs in two to three rows.



A T.S. Leaf of *Erica Tetralix* ($\times 105$).

B. T.S. Leaf of *Erica Mackayi* ($\times 105$).

C. T.S. Leaf of *Erica Crawfordii* ($\times 105$).

Anatomy.—Upper epidermal cells relatively large, tangentially elongated $32.5\ \mu \times 21.5\ \mu$, cuticularised $3.5\ \mu$ in thickness.

Short unicellular hairs may occur on the upper surface. Numerous long, rigid, glandular hairs on leaf margins.

Lower epidermal cells very small, irregular in shape, cuticularised.

Stomata small, guard cells projecting slightly above the level of the epidermis.

Simple, short, curved, papillate hairs very numerous, four to six arching over the stoma. Simple, long, straight, papillate hairs on the mid-rib.

The bundle is small, circular, almost completely surrounded by a stereome, which is more developed on the upper and under sides of the bundle. Two to three rows of parenchyma intervene between the stereome and the lower epidermis.

Xylem vessel very small, in groups of two to five.

An analysis of *E. vagans* was made but need not be quoted, since it does not add anything to the argument.

ERICA PRAEGERI (*E. Tetralix* - *E. Mackayi*).

Leaf Characters. - Leaves petiolate $\frac{2}{3}$ mm., linear-oblong (*i.e.* intermediate between *E. Tetralix* and *E. Mackayi*) $4\frac{1}{3}$ mm. \times $1\frac{2}{3}$ mm., margins revolute, exposing four-fifths of the under surface.

Glandular hairs occur on leaf margins in one to two rows: simple hairs few, scattered.

Anatomy. - Upper epidermal cells large, irregular, varying from $27\ \mu \times 30.5\ \mu$ to $21.5\ \mu \times 21.5\ \mu$, cuticularised $7\ \mu$ in thickness. Approximately 50 per cent. of the upper epidermal cells show a transverse septum dividing the cell into two more or less equal parts (*cf.* *E. Mackayi*).

Lower epidermal cells small, oblong, cuticularised. Guard cells of stomata project above the level of the epidermis.

Simple, short, curved, papillate hairs occur on the under surface, two to four arching over the stoma (*cf.* *E. Mackayi*). No hairs on the mid-rib (*cf.* *E. Mackayi*).

The bundle is ovoid in outline (*i.e.* intermediate between *E. Tetralix* and *E. Mackayi*). The stereome consists of a small patch of cells on the upper side of the bundle and a larger

patch below (cf. *E. Mackayi*). One to two rows of parenchyma intervene between the stereome and the lower epidermis (cf. *E. Tetralix*).

Xylem vessels small, in groups of two to five (cf. *E. Mackayi*).

ERICA STUARTII (*E. Mackayi* \times *E. mediterranea*).

Leaf Characters.—Leaves petiolate 1 mm., linear-oblong $3\frac{1}{2}$ mm. \times $1\frac{1}{4}$ mm., margins revolute, exposing two-thirds of the under surface.

No glandular hairs, few simple hairs, more numerous on the petiole.

Anatomy.—Upper epidermal cells small, irregular, varying from $30.5\ \mu \times 30.5\ \mu$ to $21.5\ \mu \times 18\ \mu$, strongly cuticularised $7\ \mu$ in thickness.

Approximately 50 per cent. of the upper epidermal cells show a transverse septum dividing the cell into two more or less equal parts (cf. *E. Mackayi*).

Lower epidermal cells small, oblong, and less strongly cuticularised.

Stomata large, guard cells projecting above the level of the epidermis (cf. *E. Mackayi*).

Simple, short, curved, papillate hairs occur on under surface, two to four arching over the stoma (cf. *E. Mackayi*). Long, straight, simple hairs on the mid-rib.

Bundle is small and triangular in outline, the base being parallel to the lower epidermis. The stereome consists of a small patch of cells on the upper side of the bundle and a large patch below. A layer of parenchyma intervenes between the stereome and the lower epidermis.

Xylem vessels very small, in groups.

ERICA CRAWFORDII.

Leaf Characters.—Leaves petiolate $\frac{2}{3}$ mm. oblong, 3 mm. \times $1\frac{1}{2}$ mm., margins revolute, exposing about four-fifths of the under surface (cf. *E. Mackayi*).

Lamina and petiole glabrous, except the leaf margins which bear one row of large glandular hairs (cf. *E. Mackayi*).

Anatomy.—Upper epidermal cells large, radially elongated $32.5\ \mu \times 36\ \mu$, cuticularised $8\ \mu$ in thickness. All the epidermal

cells with few exceptions show a transverse septum, dividing the cell into two approximately equal parts (cf. *E. Mackayi*).

Lower epidermal cells small, oblong, and cuticularised. Guard cells of stomata project above the level of the epidermis.

Simple, short, curved, papillate hairs occur on the under surface, two to four arching over the stoma (cf. *E. Mackayi*). No hairs on the mid-rib (cf. *E. Mackayi*).

The bundle is smaller than that of *E. Mackayi*, triangular in outline, the base being parallel to lower epidermis (cf. *E. Mackayi*). The stereome consists of a very small patch of cells on the upper side of the bundle, and a large patch below, extending to the epidermis (cf. *E. Mackayi*).

Xylem vessels small, in groups of two to five (cf. *E. Mackayi*).

DISCUSSION.

A distinctive feature which has emerged is the peculiar epidermis in *E. Mackayi*. This character appears in no other species but it is seen in the hybrids *E. Praegeri* and *Stuartii*, both of which have *Mackayi* as one of their parents. It also occurs in *E. Crawfordii*.

If *E. Mackayi* were a sub-species or variety of *E. Tetralix* it is strange—

1. That it is glabrous save for glandular hairs of the ordinary type.

2. That there should be no knuckle-bone-shaped glands.

3. That the epidermal cells should be different in size and shape, and that they should show this clear transverse wall.

4. That the bundle and stereome should differ so markedly.

If *E. Mackayi* were a hybrid between *E. Tetralix* and *E. ciliaris*, then it should be intermediate between its parents, which it is not, neither in leaf-shape, character of the epidermal cells, nor bundle and stereome characters.

E. Watsonii is a natural hybrid between *E. Tetralix* and *E. ciliaris*, resembling one of its parents strongly in some features while in others being completely intermediate.

It seems therefore that *E. Mackayi* is certainly specifically distinct from *E. Tetralix* and is not a hybrid.

Erica Crawfordii can be seen to resemble *E. Mackayi* very strongly, and is probably a form *flore pleno* of it.

E. Praegeri is intermediate between its parents *E. Tetralix* and *E. Mackayi* in

- (1) Amount of curvature of leaf.
- (2) Leaf-shape and hairs.
- (3) Character of upper epidermal cells.
- (4) Bundle characters.

SUMMARY.

The following important conclusions from the anatomy of the leaves seem to be justified :—

1. That *Erica Mackayi* is even more distinct from *Erica Tetralix* than has been thought.

2. That *Erica Crawfordii* is unmistakably more closely connected with *Erica Mackayi* than with any other species, and is almost certainly a double-flowered form of it.

3. That the Irish hybrid heath known as *Erica Praegeri*, which was described by Dr. Ostenfeld and presumed to be of hybrid origin, is in all probability correctly so regarded. At any rate, the *Mackayi* influence is unmistakable, while the *Tetralix* influence may be reasonably inferred.

THE RECOGNITION OF SOME AGRICULTURAL GRASSES BY THEIR VEGETATIVE CHARACTERS. By J. H. WHYTE, B.Sc.

(Read 23rd January 1930.)

The following key is an attempt to give the main vegetative characters of the most common of the agricultural grasses of Britain, and to act as an introduction to the grasses when they are not in flower.

I. LEAF BLADE EXPANDED.

A. SHEATH COLOURED.

(a) Hairless.

1. Sheath round.

i. Red colour.

(x) Basal margin of leaf smooth; ligule large. Veins of leaf indistinct when held up to the light. T.S. of leaf shows no girders *Lolium italicum*

(y) Basal margin of leaf rough; ligule small. Veins distinct when held up to the light. T.S. of leaf shows girders *Festuca pratensis*

ii. Dark brown or with a tinge of violet

Alopecurus pratensis

2. Sheath flat.

i. Red colour . . . *Lolium perenn*

ii. Yellow . . . *Cynosurus cristatus*

(b) Hairy.

Sheath round.

White with red veins. Tufted habit of growth . . . *Holcus lanatus*

B. SHEATH COLOURLESS.

(a) Hairless.

1. Sheath round.

i. Ribs very low and flat; basal margin of leaf upwards rough; ligule longer than broad, thin and toothed

Phleum pratensis

ii. Ribs prominent; blade rough on both sides: ligule long, hairy on the back

Agrostis alba

iii. Two tufts of hair at the junction of the leaf, blade, and sheath

Anthoxanthum odoratum

2. Sheath flat, with rounded edges.

Ribless grasses with median lines.

- i. Blade relatively thick and hard or fleshy, dark coloured when held up to the light; ligule short. Rounded apex, edges of leaf parallel. Note conspicuous motor cells in T.S. *Poa pratensis*
- ii. Blade soft and thin, light coloured when held up to the light. Leaf apex rounded, edges of leaf not parallel; ligule prominent; lower surface of leaf dull or slightly shining *Poa annua*

3. Sheath flat, edges acute.

i. Ribless grasses with median lines.

Acute apex, blade tapering from base; ligule acute; lower surface of leaf shining *Poa trivialis*

ii. No median lines.

Large ribless blades, tapering from about the middle to an acute apex; under surface of leaf dull . *Dactylis glomerata*

(b) Hairy.

i. Soft and downy.

(x) Sheath white with red veins

Holcus lanatus(y) Sheath not characteristically coloured *Bromus mollis*

ii. Not soft and downy.

(w) Blade low, acute ribs; single row of hairs along each rib; sheath not keeled, very little on blade

Arena flarescens(x) Blade with low, flat ribs, hairs sparse, sheath keeled *Arena elatior*

(y) Small round ears at base of blade, also beard of hair

Anthoxanthum odoratum

(z) Base of leaf with pointed ears; ligule reduced to a mere margin; fringed with teeth like hairs

Triticum repens

II. BRISTLE BLADED GRASSES.

i. Ligule conspicuous—thick and obtuse. T.S. of leaf shows girders to some or all of the vascular bundles *Nardus stricta*

ii. Ligule inconspicuous—ear-like ligule at base of culm leaf. T.S. No girders

Festuca ovina

When using the key the following hints should be kept in mind. The easiest method to test for the roughness of the leaf margin is to draw it backwards and forwards along the

tip of the tongue. The type of rib is best detected by bending the blade round the finger and examining the upper surface. Hairiness is best seen by looking along the surface of a grass and not at it. The median lines, which are best seen when the leaf of any of the *Poas* is held up to the light, are two parallel lines of lighter tissue; these lines run along the centre of the grass blade and are separated by a dark band of tissue. The term "girders" is used to indicate the bands of strengthening tissue which are sometimes found stretching from the vascular bundles to the epidermis.

REFERENCES.

- ARMSTRONG, S. F. : British Grasses and their Employment in Agriculture, 2nd ed. (1921).
LEWTON-BRAIN, L. : On the Anatomy of the Leaves of British Grasses. Trans. Linn. Soc., ser. 2, vi (1904), pp. 315-359.
MCALPINE, A. N. : How to Know Grasses by the Leaves (1890).
STEBLER, F. G., and SCHROTER, C. : The Best Forage Plants. Trans. A. N. McAlpine (1889).

THE SPREAD OF BRACKEN BY SPORES.

By J. H. WHYTE, B.Sc.

(Read 24th April 1930.)

Bracken is generally believed to spread mainly by vegetative means, and that the increase due to the germination and development of spores is very rare. The following notes are intended to show that the spread of bracken by spores is neither impossible nor rare.

An interesting case where bracken may have increased by means of spores can be seen from the Corrie slopes of Ben Lui. On the hills opposite there are hundreds of small bracken patches above the tree-line, which appear to be most frequent in the smaller valleys and near water. Professor Braid of the West of Scotland College of Agriculture is of the opinion that they must be due either to fresh infections or to the breaking up of the old continuous areas. Considering the position of these patches, mainly near moisture, one of the chief factors in the development of fern prothalli, and away from trees which alone could suppress bracken in such a site, one is inclined to believe that these are fresh infections due to spore dissemination.

In the field when examining plants thought to be sporelings great care must be taken, as is shown in a case quoted by Professor Braid. He found tiny plants on very wet ground which appeared to be sporelings, but after being removed from the soil were found to be attached to the remains of a large rhizome, and were the last stages of a bracken area which had been drowned out. Farrow (1) has found sporelings in the mouth of a rabbit burrow which was far removed from a bracken area. Such a case is open to doubt, as there is no reference as to whether or not a plant was dug up in order to ascertain if there was any suggestion of old rhizome present, since there is the chance of a piece getting there by mechanical agencies.

Margaret Benson and Elizabeth Blackwell (2) mention definitely the establishment of bracken by spores. Cases equally well authenticated, though not published, have

occurred in Scotland. Professor Lang of Manchester University found prothalli and sporelings in all stages of growth on Flanders moss on the site of a fire; also Professor Bower mentions a profuse growth of prothalli which was found on peat sent into Glasgow Botanic Gardens.

W. J. Lucas (3) states: "Should anyone wish to ornament a corner of a garden by means of a clump of bracken, a piece of rhizome must be procured; or, better still, tiny plants that have developed from spores on a patch of charcoal and earth, or where fir branches have been burnt in Ester Woods. I can say from experience how a fine bed of bracken some 3 feet to 4 feet high may be obtained in three to four years from tiny plants only an inch or two in stature."

In the paper by M. J. Laurent (4) there are references to the establishment of bracken after the prevailing vegetative community has been upset. "Burnt soil rich in phosphate of potash contains also particles of charcoal which hinder growth of fungi. This gives a proper medium for the germination of spores and the growth of the prothallus."

Thus we see that a favourite place for the establishment of bracken from spores is on the site of a fire. M. J. Laurent (4) is of the opinion that this is due to the presence of the charcoal, but a more likely explanation is that the fire has sterilised the surrounding soil, and that it is due to the fire, and not to the presence of the charcoal, that fungal growth is prevented and germination of bracken spores takes place.

In a bracken community the struggle for existence is intense, and the community is spoken of as a closed phase. But if such a community is partially opened there is a chance of the bracken sporelings growing. The presence of moisture is also essential for the development of the bracken plant from the prothallus. Thus we see that in certain seasons and under certain conditions we do get the establishment of bracken by means of the spreading of spores.

In conclusion I should like to express my indebtedness to Professor Braid of Glasgow, who gave me many helpful suggestions, and to Professor Bower and Professor Lang for permission to publish some data supplied by them.

REFERENCES.

- (1) FARROW, E. PICKWORTH: Plant Life on East Anglian Heaths, 1925.
- (2) BENSON, MARGARET, and BLACKWELL, ELIZABETH: Observations on a Lumbered Area in Surrey from 1917-25. Jour. Ecol., xiv (1924).
- (3) LUCAS, W. J.: Bracken (*Pteris aquilina*). Proc. S. London Entomol. and Nat. Hist. Soc., 1911-12.
- (4) LAURENT, J.: Sur l'introduction récent du *Pteris aquilina* en champagne pouilleuse. Bull. Soc. Bot. France, lxi (1914), p. 75.

EXPERIMENTS WITH VITA GLASS. By R. J. D. GRAHAM
and L. B. STEWART.

(Read 24th April 1930.)

Reports on the value to horticulture of glass which permits the passage of ultra-violet rays are contradictory as regards the effect on growing plants (Jour. Roy. Hort. Soc., lv, 1930, 79). Commercially the results are uniformly adverse, as neither the increased crop, earliness, nor the saving in time compensates for the increased capital outlay incurred by the installation of special glass.

Experiments were carried through at the Royal Botanic Garden, Edinburgh, between May and September 1929. Small frames, outside measurements 21 inches by 23 inches by 28 inches, were glazed on all sides and tops with Vita Glass. Controls were glazed with glass of the same thickness as Vita. The top of each frame could be elevated for ventilation. In all twelve frames, six Vita and six Ordinary Glass, were employed. The series of twelve frames was arranged in two sets permitting the height of the top to be either 28 inches or 21 inches from the ground.

The frames were placed on beds consisting of light loam previously cultivated, without the application of manure. Seeds were drilled uniformly in the frames, and after germination the seedlings were thinned to give an equally spaced stand of plants. All cultural operations, including watering and ventilation, were carried out similarly for each set of frames.

Throughout the course of the experiment the amount of ultra-violet light reaching the plants was measured by an acetone methylene blue gauge.

The monthly records in gauge units are :

	Vita.	Ordinary.
May . . .	55	44
June . . .	78	50
July . . .	50	39
August . .	35	27
September .	31	24

The crop was weighed immediately after removal from the soil. In addition, where crops are cultivated for special parts, these were separately weighed.

EXPERIMENTS : (1) TURNIPS.

Golden Ball and Milan Purple Top were sown on 30th April, and harvested on 12th and 20th June respectively. A second sowing of Milan Purple Top was made on 29th May and harvested on 7th July.

			Weight of Whole Plant in Ounces.	Weight of Roots.	Methy- lene Blue Units.
Golden Ball . . .	{ Vita	Ordinary	186	35	76
			168	37	62
Milan Purple Top. First Crop	{ Vita	Ordinary	81	40	106
			98	43	78
.. Second Crop	{ Vita	Ordinary	74	41	103
			75	38	67

Analysis revealed no difference in composition in Milan Purple Top grown under Vita Glass and Ordinary. In both the moisture was 91.7 per cent.

(2) RADISH.

A sowing of White Turnip Radish was made on 12th June, and harvested on 15th July. A second sowing was made on 28th June along with a sowing of Scarlet Globe Radish, both being harvested on 4th August.

			Weight of Whole Plant in Ounces.	Weight of Roots.	Methy- lene Blue Units.
Turnip White, First Crop .	{ Vita	Ordinary	32	18	74
			38	30	45
.. Second Crop	{ Vita	Ordinary	55	13	57
			33	10	43
Scarlet Globe . . .	{ Vita	Ordinary	45	26	57
			31	18	43

(3) BEETROOT.

Bell's Deep Blood Red and Half-long were sown on 8th July and harvested on 27th September.

		Weight of Whole Plant in Ounces.	Weight of Roots.	Methy- lene Blue Units.
Bell's Deep Blood Red	{ Vita	156	48	100
	{ Ordinary	133	37	80
Half-long . . .	{ Vita	118	47	100
	{ Ordinary	131	57	80

(4) VARIOUS.

Dwarf Green curled Savoys were planted on 30th April and removed on 22nd July. Buckwheat was sown on 1st May and harvested on 27th June. Maize was sown on 2nd May and harvested on 30th June. Carrot, St. Valery, was sown on 13th July and pulled on 27th September.

		Weight of Whole Plant in Ounces.	Weight of Roots.	Methy- lene Blue Units.
Savoy . . .	{ Vita	184	..	169
	{ Ordinary	147	..	121
Buckwheat . . .	{ Vita	79	..	126
	{ Ordinary	66	..	90
Maize . . .	{ Vita	55	..	133
	{ Ordinary	67	..	94
Carrot . . .	{ Vita	51	20	93
	{ Ordinary	59	24	86

SUMMARY.

1. Results favourable to Vita Glass were obtained with Savoys, Bell's Deep Red Beet, and White Turnip Radish in the second crop.

2. Significant results unfavourable to Vita Glass were obtained in Maize, Half-long Beetroot, and in the roots of White Turnip Radish in the first crop.

3. The average ratio of transmission of ultra-violet rays during the experimental period by Vita and Ordinary Glass was 5·4, the maximum being in June, when 8·5 was obtained.

Our thanks are due to Professor F. G. Baily for many suggestions in connection with the measurement of light, to Professor P. S. Lelean for assistance in obtaining the methylene blue gauge, and to Mr. J. J. Blackie for analysis of the Turnip crop.

VEGETATIVE PROPAGATION OF BROCCOLI FROM HEADS. By
R. J. D. GRAHAM and L. B. STEWART. (With Pl. XV.)

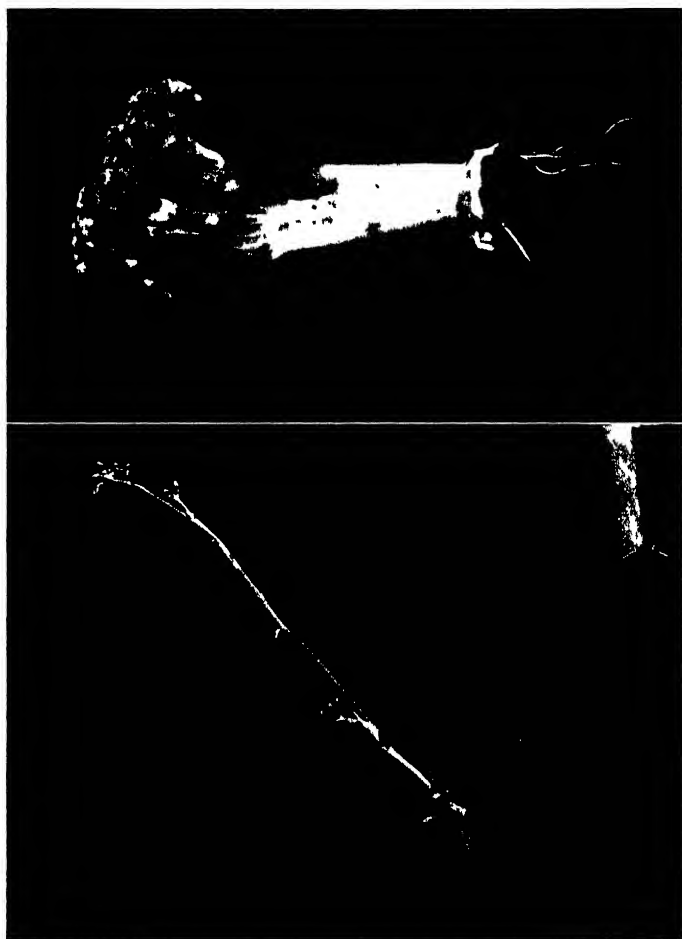
(Read 15th May 1930.)

The propagation of young flowering shoots of plants for ornamental purposes is well known in horticulture, but so far as the authors are aware the propagation of broccoli from the sterile inflorescence is recorded now for the first time. Almost a century ago, however, a method of propagating cabbage was described ("Gardeners' Magazine," ix (1833), 226). The experiments were undertaken in response to an appeal for assistance from the School of Agriculture, Cambridge.

The material received in a crate consisted of twenty-four heads. These were exploited in various ways, the most satisfactory material proving to be pieces of curd consisting of a portion of the sterilised inflorescence with the attached scale leaves. The most satisfactory environment was one with low humidity, good ventilation, and a night temperature of 55° F. Thus treated, roots developed in twenty days (fig. A), and after a further period of twenty days elongation in the flower axis had taken place with accompanying enlargement and development of chlorophyll in the scale leaves. So successful was the subsequent development that in the first week of June—the experiments having commenced at the end of February—normal flowers opened (fig. B).

Detached green leaves with a shield-like portion of stem attached also rooted freely, and though giving promise of better plants, have been markedly slower in development. Portions of curd with green leaves attached were also rooted, but at a later stage the curd decayed, causing the death of the cutting.

This method of propagating broccoli opens the possibility of securing seed when, for special reasons, seed cannot be otherwise obtained. Owing to self-sterility in certain members of the genus *Brassica*, and particularly in broccoli, it is advisable to propagate from several heads in order to overcome this difficulty.



A

Rooted Broccoli inflorescences

B

SUMMARY.

1. Propagation of broccoli from the sterile inflorescence is described.

2. To obtain seed, the propagation of portions from more than one plant is recommended.

DEVELOPMENT AND ANATOMY OF MONOCOTYLOUS SEEDLINGS.

1. *PARIS POLYPHYLLA*. 2. *COSTUS SPECIOSUS*. By LUCY BOYD, B.Sc.

(Read 15th May 1930.)

1. *PARIS POLYPHYLLA*.

Although a copious literature dealing with Liliaceous seedlings exists, very little refers to the tribe Medecolae and no account was found of the germination of the British *Paris quadrifolia* or of the Himalayan species, *P. polyphylla*. The present investigation consisted of an examination of fourteen seedlings of the latter at various stages of development.

The embryo is a small, undifferentiated body (2) lying in very hard endosperm, the seed being enclosed in a berry. The seeds germinate after seven months. The primary root emerges, followed by the base of the cotyledon which ensheathes the plumule and carries it deeper into the soil. The cotyledon is differentiated later into :

(i) A sheathing base, the limits of which cannot be determined from the external morphology : it functions as a food-storing as well as a protective organ.

(ii) A cylindrical stalk, curved in the young seedling (fig. 1, 1a), later erect : its length is 6 mm. and it is grooved on the adaxial side in a six-months-old seedling.

(iii) A broad distal portion with inrolled margins and tip imbedded in the seed. In a few months it erects itself and expands to a green lamina, which continues to increase in width and length. In shape it is cordate : ocelli on the margin give it a finely serrated appearance. Its strong midrib is reinforced by a reticulum formed of 3 4 pairs of laterals. The two lower pairs of laterals tend to converge with the midrib at the base. This is repeated in the first foliage leaf, which is similar in shape (fig. 1, IIIa). Finally, in the leaf from a whorl on the floral axis, three pairs of laterals diverge from the base.

Development of the plumule is slow. After four or five months a short outgrowth emerges laterally, below soil level, from the swollen base of the cotyledon (fig. 1, 1a). Its course

is slightly oblique and it pushes out the epidermal layers of the sheath. The primary root is a powerful organ, stout and

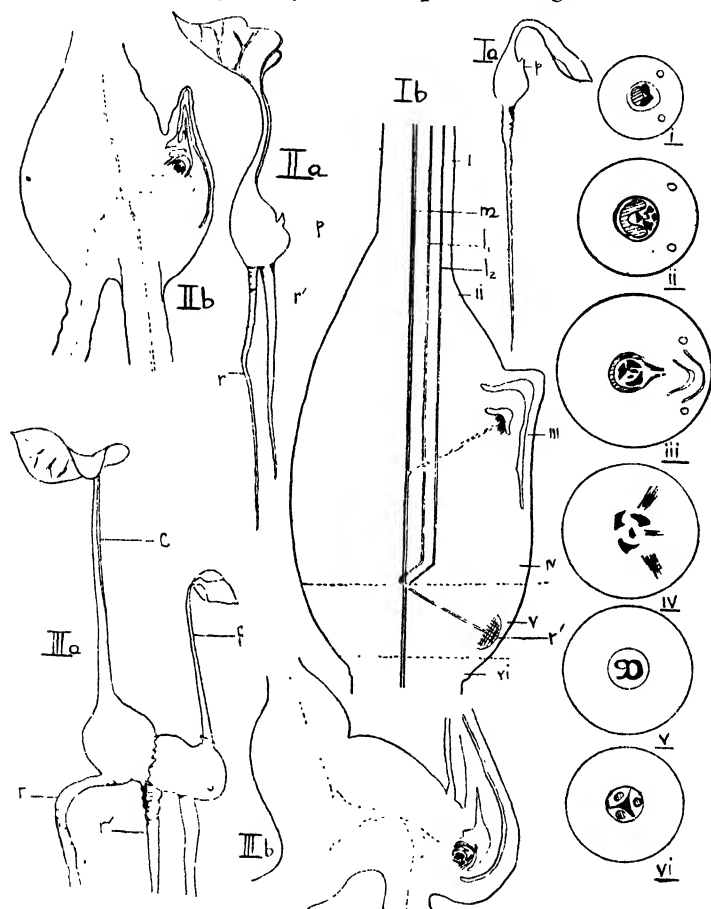


FIG. 1.—*Paris polyphylla*. Ia. Four-months-old seedling. b. Longitudinal section of a showing levels corresponding to transverse sections i-vi, horizontal dotted lines indicate the limits of the hypocotyl; development of the rhizome is seen in a six-months old (IIa, b) and a year-old (IIIa, b) plant, dotted lines showing course of vascular strands.

c=cotyledon; f=first foliage leaf; m=main strand of cot; p=plumular bud; l₁, l₂=two lateral strands of cot; r=primary root; r'=cauline root.

tough, its length always greater than that of the aerial part of the plant. It early assumes a contractile function due to the collapse, in bands, of cortical cells. Its work is unshared

by cauline roots for six months, although meristem for such is laid down almost from the beginning of germination.

Anatomy of Four-months-old Seedling.—The lamina of the cotyledon has an upper epidermis of large thin-walled cells, a layer of small palisade cells, well-ventilated mesophyll, and a lower epidermal layer consisting of small regular cells. Phloem and xylem are equally developed. In the stalk portion (fig. 1, i) one central strand, a double bundle, runs through a ground mass of parenchyma, accompanied by two smaller lateral strands, each enclosed in a sheath. The stalk gradually merges into the sheathing base, with its widening storage region. At the level where the plumular bud arises (fig. 1, ii and iii) the central strand becomes less compact and a crescent of phloem disposed opposite to the plumular faces three xylem groups. The vascular tissue supplying the plumule makes little change in this arrangement. Below this level a central protoxylem and four metaxylem groups are scattered in a ground-mass of phloem and parenchyma. The lateral strands of the cotyledon fuse with the central strand, 0.5 mm. lower, a region which may be taken as the upper limit of the hypocotyl (fig. 1, iv, and Ib).

In the hypocotyl there is an increase in girth of cortical storage cells packed with starch grains, and isolated raphides occur. The stele is ensheathed by an endodermis. The transition is slow, the hypocotyl being 0.5 mm. long. The xylem, seen in transverse section at this stage, is disposed in closed or open rings, which are buttressed outside and inside by phloem. These rings disintegrate, the protoxylem is orientated outwards and the phloem rearranges itself, giving finally a typical triarch root stele, marking the lower limit of the hypocotyl. Externally, however, there is perfect continuity of epidermis and swollen cortex; the diameter is 1.5 mm., which does not differ perceptibly from the maximum. There is a sudden diminution in the width of the cortex at a stage 0.2 mm. lower, and the root assumes its usual appearance. Near its tip, the root has a diarch, then a monarch stele.

Development of the Rhizome.—The lateral position of the plumule and the oblique direction of its strands are obvious in the youngest seedlings (fig. 1, Ib). In a six-months-old seedling the strands from the first foliage leaves and plumular meristem follow an almost parallel course, horizontally (fig. 1,

IIa, b), converging in the centre of the swollen mass to meet the cotyledonary tract which has been diverted from the vertical. A strong, efficient cauline root is produced, immediately below the plumular bud, in order to meet its requirements, in its somewhat isolated position, thus giving a more balanced arrangement but throwing the primary root into an apparently lateral position.

The horizontal traces in a year-old seedling (fig. 1, IIIa, b) function as the vascular system of a rhizome with the plumule at the end of the first node, protected by young leaves. The base of the cotyledon and hypocotyl still persist at the other end covered by the original epidermis, which has been ruptured by the growth of the rhizome. The cotyledonary strand maintains connection with the plumule by a necessarily indirect course and also with the primary root. A single foliage leaf appears above the soil in the first season. After a further year's growth the rhizome is deeper in the soil and about 7 mm. in length (3 mm. of this being the original hypocotyl). A thin membrane covers the rhizome and overlaps the sheaths at the point of the rhizome, which is monopodial. In this second year the first axis bearing a whorl of leaves appears - the whorl consisting of three, four, or five leaves.

The seedling is noteworthy for its simplicity of structure and slow development of the plumule, which results in the relegation to the cotyledon of photosynthesis and food storage for the first year. The similarity between the cotyledon and first foliage leaf is interesting, as is the early indication of a horizontal monopodial rhizome. It was hoped that the slow ontogenetic development might reveal points of phylogenetic value, and the fairly lengthy transition in a hypocotyl of measurable dimensions gives sections with steles reminiscent of the dictyostele and solenostele of Ferns. It is difficult to say, however, how far these are the result of the tuberous nature of the hypocotyl. Such steles were not found in the hypocotyl of *Trillium oratum*, a closely allied and very similar plant, nor in seedlings of the Araceae, which in their habit bear a resemblance to *Paris*.

2. *COSTUS SPECIOSUS*.

In addition to its own peculiar features, the seedling of this plant affords an interesting comparison with that of *Paris*.

Costus is the sole genus in the sub-family Costoideae which, with another Zingiberoideae, composes the Zingiberaceae

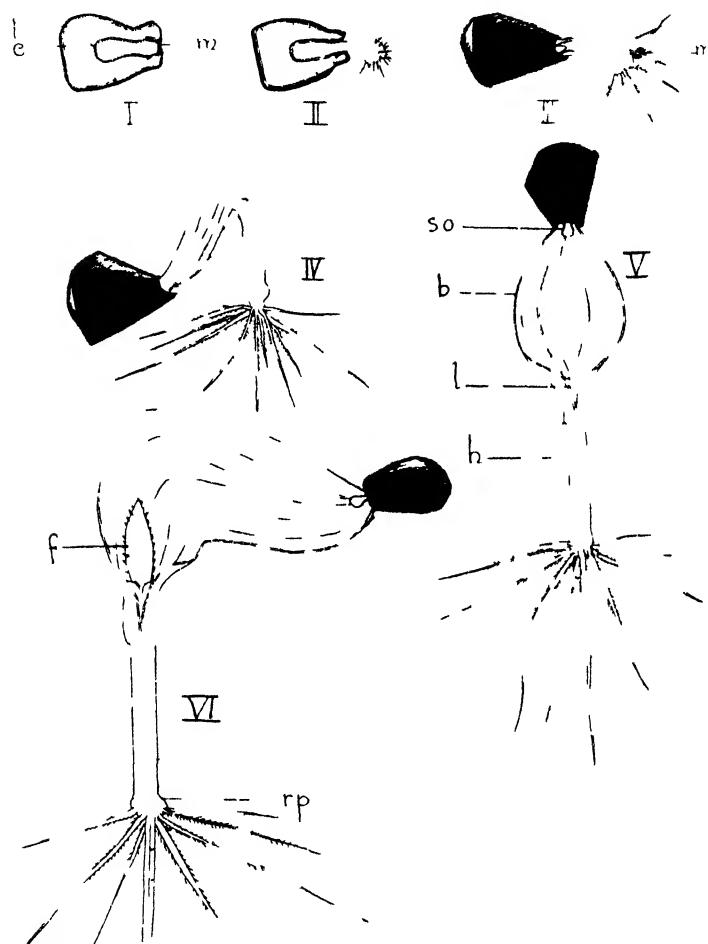


FIG 2—*Costus speciosus* I Ripse embryo II IV Seedlings one, two, and three days old V Six weeks old seedling VI Twelve weeks old seedling

b—blade of cotyledon, f—first foliage leaf, e—endosperm, p—perisperm
h—hypocotyl, so—spherical outgrowth, m—germinal lid
rp—root plate, l—ligule

The phyllotaxy, which is an important diagnostic feature in the division into sub-families, is abnormal in *Costus*, as Landmann (5) has pointed out Further, the study of the

seedling was recommended in 1896 by Humphrey (4) who made a thorough investigation of the seed before germination. He describes a highly differentiated embryo (fig. 2, I), cylindrical and straight with two or more rudimentary leaves and four accessory roots, lying in a copious endosperm of aleurone, surrounded by a starchy perisperm. A lid closes the testa at the mouth of the micropylar collar, with which, however, it is not in organic continuity. On germination the lid is pushed out. A definite precise mechanism for the emergence of the radicle therefore exists. The type of germination is similar to that of *Paris*. The seeds germinated in three weeks, and seven were examined.

One-day-old Seedling.—Marked elongation of that part of the embryo behind the radicle results in the emergence of the latter, covered with a mass of root hairs (fig. 2, II). *Twenty-four hours later* (fig. 2, III) eight strong rootlets of cauline origin (four of them doubtless Humphrey's accessory rootlets) arise, arranged in a ring on the wide basal region above the pointed apex, which represents the primary root. The cylindrical region, embodying hypocotyl and base of cotyledon, is unchanged, but there is now visible a short flattened portion of the cotyledon with incurved margins. A small green spherical outgrowth, $\frac{1}{2}$ mm. or less in diameter, blocks the circular micropylar opening.

Three-days-old Seedling (fig. 2, IV).—The flattened part is the blade of the cotyledon, ribbon-like, photosynthetic, fleshy and with parallel venation, terminated at one end by the green outgrowth, at the other by its fusion to the axial portion of the seedling. The blade is bent, for the suctorial tip is in the seed which is at the level of the soil. It becomes erect and carries the seed at its tip after seven days.

Six-weeks-old Seedling (fig. 2, V).—The cotyledon blade has lengthened to 12 mm., widened to 9 mm., and increased in thickness. The first leaf is to be seen, its adaxial side closely adpressed to the blade of the cotyledon. Its base is well protected by a small, green, ligular collar of fleshy tissue (fig. 2, V, I), to which it is almost fused. This sheath is more conspicuous in the oldest seedling examined (fig. 2, VI), which shows increased growth of the lamina of the cotyledon and the system of cauline roots. The shortness of the latter, which grow from a stout root plate at the base of the lengthy

hypocotyl, is compensated for by their number and arrangement, which give good anchorage to the plant.

Anatomy of three-days-old Seedling (fig. 3).—Six vascular strands traversing the cotyledonary tip are reduced to five at the micropyle, after which the cotyledon assumes an elliptical,

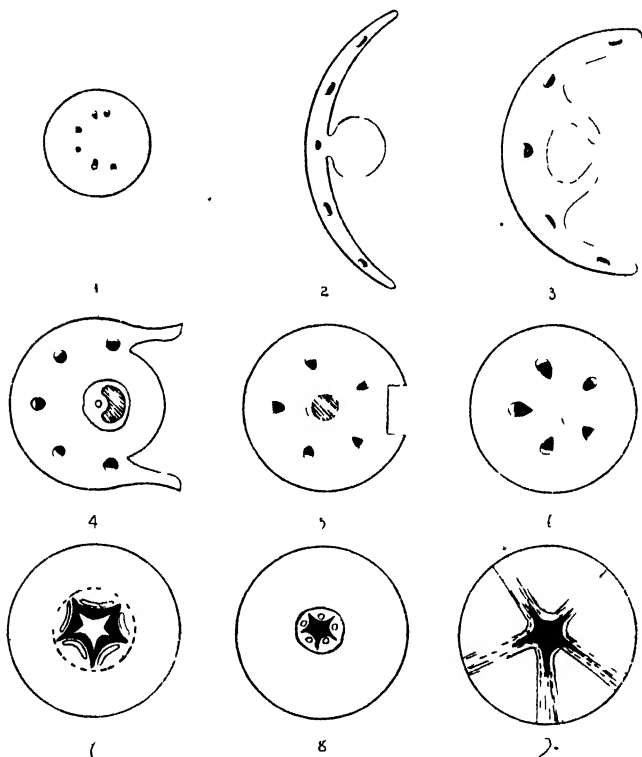


FIG. 3.—*Costus speciosus*. Sections of seedling \ in fig. 2 taken from tip of cotyledon downwards to the root plate (diagrammatic)

then a more flattened cross-section. At this juncture the green spherical outgrowth appears on the upper side of the cotyledon, opposite the midrib. The vascular strands are unaffected by its presence. It is non-vascular (fig. 4), with a thinly cutinised epidermis, provided with numerous stomata.

The internal tissues of the blade of the cotyledon are well differentiated. Lower and upper epidermis are identical, stomata occurring in both. The sub-epidermal layer on each

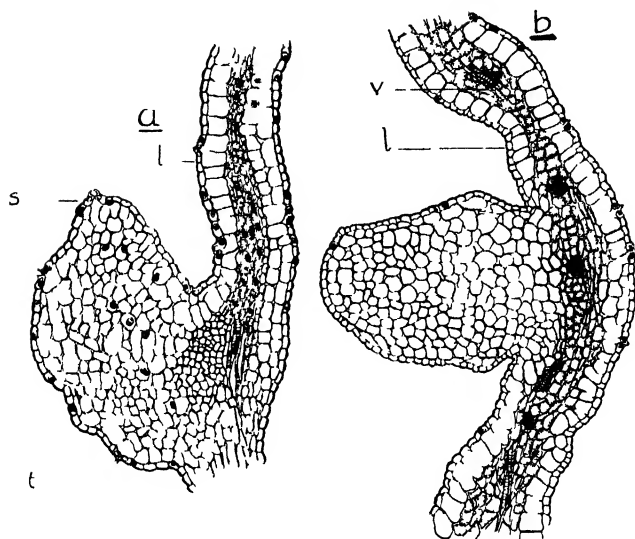


FIG. 4—*Costus speciosus*. a Median longitudinal section through lamina of cotyledon where outgrowth occurs b transverse section of a (Camera lucida drawing.)

s = stoma l = lamina of cotyledon v = vascular strand of cotyledon
t = suctional tip of cotyledon

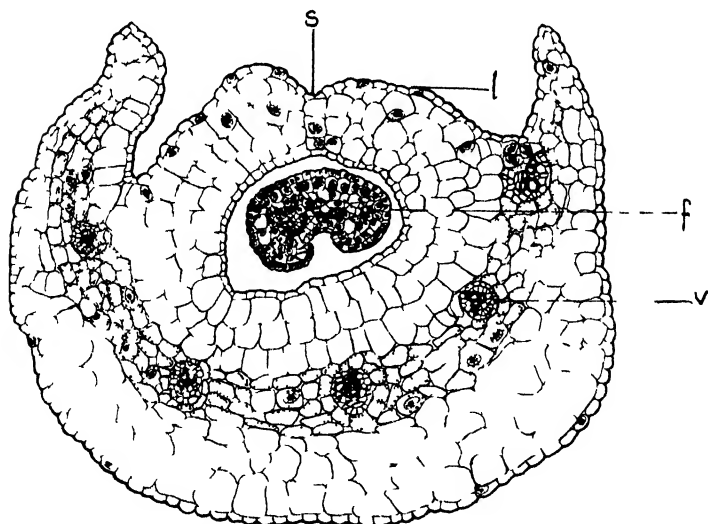


FIG. 5—*Costus speciosus*. Transverse section through the basal end of the blade of the cotyledon showing the origin of the ligule (Camera lucida)

l = ligule v = vascular strand of cotyledon f = first leaf of plumule
s = region of weakness where slit will occur

side functions as a water-storage region. The photosynthetic tissue consists of mesophyll. At the base of the lamina the margins curve inwards (fig. 3, 3rd section). The layer of sub-epidermal cells on the upper surface is replaced by four layers of parenchyma which arch outwards and bridge the gap between the two margins (fig. 5). This arch indicates the beginning of the sheath protecting the plumule and is non-vascular. The necessity for it is apparent, for the margins of the blade make no attempt at overlapping or fusing with each other.

Externally only a slight decrease in diameter marks the upper limit of the hypocotyl. A central cylinder of compact tissue, consisting chiefly of five plumular traces, is surrounded by a ring of five massive cotyledonary traces disposed at equal intervals on the inner periphery of a broad cortical zone (fig. 3, 6). The cotyledon strands pass to the centre at a level $150\ \mu$ lower. The stele has a ring of xylem with ten protoxylem rays, between which lie small patches of phloem. It quickly changes to a medullated pentarch form, which is constant throughout the length of the hypocotyl: at the base, the xylem becomes consolidated to a plate from which cauline roots arise (fig. 3, 9).

The above arrangement is typical, but in older seedlings the greater number of plumular strands fusing with the cotyledonary traces complicate the hypocotylar structure; in the oldest seedling, for example, two very weak traces descend through the wide pith of the stele in the hypocotyl.

No adequate explanation can be put forward to account for the outgrowth at the distal end of the cotyledon. It may act as a stopper, closing the circular aperture of the testa, yet none exists in seedlings with a like germination mechanism, e.g. *Commelina*, *Hemerocallis*. The absence of vascular tissue disposes of the suggestions that it is a hydathodal structure on a large transpiring surface, or a result of the buckling up of vascular traces in their passage from a wide lamina to a microscopic cylindrical tip. That it is a vestigial structure, remaining from a period when the cotyledon was not differentiated into lamina and tip but was cylindrical and partly solid, is problematical. The difficulty in deciding its nature is comparable to that raised by the epiblast of the seedlings of some Gramineae (3). This is also a small non-vascular structure, the cotyledonary origin of which is less

clear owing to the more complicated form of the grass embryo with plumular axis and cotyledon fused. Further speculation in this connection is raised by considering the resemblances existing between the grasses and Zingiberaceae. The German systematists consider the Scitamineae a series co-ordinate with the Glumiflorae, and Sargent and Arber (7), in their study of the comparative morphology of the grass embryo, draw much of their evidence from the anatomy of seedlings of Zingiberaceae.

The biological necessity for the ligular sheath at the base of the cotyledon lamina is apparent, for the cotyledon as a sheathing organ is useless. Its interest lies in that it is not that prolongation of the sheathing base into a hood, seen so commonly in the monocotyledonous seedling and designated "ligule," but a true ligule such as develops on the leaf of the adult *Costus* and is typical for the leaf of Zingiberaceae. A seedling such as *Gloriosa* (Liliaceae), or *Tygridia* (Iridaceae), figured by Arber (1), requires no marked photosynthetic activity on the part of the cotyledon, the chief work of which is protection, achieved by the adoption of the hooded "ligular" form. The plumule of *Paris* is adequately protected by the sheathing base, so the dominant part of the cotyledon is green lamina, with no ligule. *Costus* compromises between the two types. The continued growth of the hypocotyl, giving strength and mechanical efficiency, with its hollow, cylindrical stele, are a response to the increasing demands of the cotyledon for better support and light.

Seedlings of the Zingiberoideae resemble *Costus* in the type of embryo, endosperm, and seed, in their almost entirely adventitious root system and in the insignificant, if not actually absent, basal sheath of the cotyledon. On the other hand, they lack the lengthy hypocotyl and green cotyledonary blade of *Costus*, and even a stalk homologous to the blade is absent. They have no open ligular sheath, but a cotyledon consisting chiefly of hooded "ligule" (7, text-figs. 31, 34). The first leaf of *Costus* is a true foliage leaf, not an attempt at one; in the majority of Zingiberoideae the true adult form of leaf is not produced until one or more simple scale leaves have preceded it. All the Zingiberoideae examined have in the cotyledon two strands equivalent to Sargent's "double bundle" (6). *Costus*, however, has a large number of strands

(five and upwards) and, as frequently happens in such cases, not a constant number.

Their geographical distribution points to the Zingiberaceae being an ancient group, and the sub-family Zingiberoideae show in their seedlings primitive features. The requirements of the adult form, and consequent physiological demands, upon the young plant have been such that the seedling could afford to be conservative. In its endeavour to obtain maximum light, *Costus* broke away from its relations in adopting a new phyllotaxy. The above observations seem to indicate that, having lost in the ontogeny all stages that mark a simple structure, it has likewise evolved for itself a precocious type of seedling, which shows, from the beginning, not only advanced differentiation and remarkable efficiency in structure, but also several features belonging to the adult plant.

Thanks are due to Professor Wright Smith for providing facilities for this study, to Professor J. R. Matthews and Dr. R. J. D. Graham for their interest and encouragement, and to Mr. L. B. Stewart, through whose agency the seedlings were obtained.

SUMMARY.

1. The seedling of *Paris* develops slowly. During the first year the cotyledon is the sole food-manufacturing and chief storage organ. The hypocotyl also is swollen with starch.

2. The anatomy is simple. The lateral strands of the cotyledon pursue a very long course before joining with the main strand at the upper limit of the hypocotyl, which is lengthy. The transition to root structure takes place gradually.

3. The initiation and development of a monopodial rhizome are described. The cotyledon resembles the first leaf in shape and veining.

4. *Costus*, in its seedling structure, presents a striking contrast to the nearest related group, the Zingiberoideae. In addition to an unusually strong development of cotyledonary lamina and hypocotyl, two further morphological features fall to be explained: the one, a green spherical outgrowth from the upper surface of the cotyledon where it enters the micropyle of the seed; the other, a ligule arising from the basal end of the cotyledon and similar to that of the adult *Costus* leaf.

5. It is concluded that the adult form of *Costus* expresses

itself in the seedling from the earliest stages, no traces of primitive characters such as are seen in the Zingiberoideae, being therefore observable.

REFERENCES.

- (1) ARBER, A.: *Monocotyledons: a Morphological Study*. Cambridge, 1925, p. 161.
- (2) GAERTNER: *de Fructibus et Seminibus Plantarum*, 1791, ii, p. 19.
- (3) GOEBEL: *Organography of Plants*, ii, p. 418.
- (4) HUMPHREY, J. E.: *Development of the Seed in Scitamineae*, *Ann. Bot.*, x, 1896, p. 1.
- (5) LINDMANN, C. A. M.: *Bihang. Sv. Vetensk Akad. Handl.*, xlv, 1899. *Bot.*, n. 4, 36.
- (6) SARGANT, E: *The Origin of Monocotyledons founded on the Structure of their Seedlings*. *Ann. Bot.*, xvi, 1903, p. 50.
- (7) — and A. ARBER: *The Comparative Morphology of the Embryo and Seedling in Gramineae*. *Ann. Bot.*, xxix, 1915, p. 209.

FLOWER COLOURS AS NATURAL INDICATORS.

By EDITH PHILIP SMITH, B.A., Ph.D.

(Read 19th June 1930.)

The colours of flowers can be roughly divided into three groups, according to the nature of the pigments involved. Firstly, the pure rose, crimson (and a few scarlet), magenta, and blue series, which owe their colours to anthocyanins (water-soluble sap-pigments). Secondly, the yellow, orange, brown-red series, due to plastid pigments; and lastly the cases where the two types of pigment exist together and modify the final colour. It is proposed to deal with flowers from the first group only.

The use of extracts from coloured flowers, that is, of anthocyanins, as indicators of acidity and alkalinity is an old one; "Syrup of Violets" is mentioned by Robert Boyle (1) in 1664. The tincture developed a bright cherry-red on addition of acid, and a clear green on the addition of alkali. Such crude and unstable indicators as this watery mixture of anthocyanins find no place in the modern battery of sulphone-phthaleins, etc. However, an attempt has been made to study the reaction of the cell-sap of some coloured flowers by using the plant's own pigment as an "indicator," in solutions of known pH value, and comparing these standards with the colour displayed by the cell-sap in the living petal. Buxton and Darbishire (2) made observations on the reaction of the cell-sap of some flowers, but they used watery extracts of dried flowers and titrated them after various periods. When the extracts were treated immediately, little difference was found between the reaction of red (pH 6) and blue (pH 6.5) flowers. After two to three months, extract of blue flowers had a pH of about 7, and the red about pH 5.5. The flowers used include *Delphinium*, *Viola*, *Lupin*, *Rose*, *Peony*. The writers suggest that red flowers have a "selective permeability," admitting the hydron but excluding potassium ion, etc. The blue flowers are assumed to have lost this selective action, hence their more alkaline reaction. Without entering into this

theoretical discussion, it seems to the present writer that the use of living, unmutilated material for comparison avoids death changes and upsetting of the buffer system of the cells. The solutions used for making the colour-standards are sufficiently well buffered to be unaffected by the plant tissue during the extraction of the pigment.

The writer's attention was first called to this interesting possibility by observing the diurnal colour changes of the short-lived flower of the Morning Glory, *Ipomoea Leeri*. These flowers expand from tightly-rolled, magenta-pink buds to fully-opened pure blue trumpets in a very short time (the exact time depending on the temperature at which they are growing). In a few hours the flower begins to fade, changing through violet back to the original magenta, while the corolla crumples inward and rolls up round the mouth of the tube. Obviously this short period of intense activity is accompanied by a change in the reaction of the cells of the corolla. An attempt was first made to determine the pH value corresponding to the colour-stages of the flower, and then to use this in an examination of the effect of external conditions on the daily rhythm.

METHOD.

In order to determine the reaction of the corolla cells it was necessary to compare them with a standard. The standard series of colours was prepared by extracting the pigment direct into buffer solutions of various pH values, as follows: 5 c.c. of buffer solution were put in a hard-glass test-tube and warmed in a water-bath. The expanded part of a single corolla was cut off and placed in the buffer. Colour began to diffuse out immediately. The tube was quickly brought to boiling-point and kept boiling ten seconds. On cooling, the tissue was seen to be practically colourless. The coloured liquid was decanted to a fresh tube and sealed. The buffers used for this flower were Palitzsch's boric acid M/5-borax M/20 (Clarke (3), p. 88). Comparisons were made with buffer solution which had been boiled for an hour; also by making an extract of the pigment in water and adding in the cold to the buffer. No appreciable difference could be detected between tubes prepared in this way and by direct extraction, so the simpler method was used in all subsequent experiments. It was found that the pre-

pared tubes kept remarkably well if carefully sealed, but there was no occasion to use old standards when fresh ones were so easily prepared. The comparison of the standard colours with the flower-petal was made by means of Pantin's method (8). A portion of corolla was mounted in water on an ordinary micro-slip with a thin cover-glass. By means of the sub-stage condenser, an image of the standard colour-tubes can be focussed in the plane of the object, and by using the mechanical stage it is easy to bring the cells at the edge of the petal alongside of the standard. By using the untouched petal-edge one can actually examine the cells one by one. The most accurate matching was carried out by dispensing with the microscope mirror. The standards were held in a rack standing on a piece of bristol board, the microscope being mounted on a block so as to permit of direct use of the condenser. To avoid the curvature and refracting edges of the image of a test-tube, use was made of the capillary tubes supplied in the B. D. H. Capillator. Three were used for each tint, mounted side by side.

The same method was used with the other flowers examined, and details of the other buffer-mixtures will be found under the corresponding flowers.

RESULTS WITH IPOMOEA LEERII.

The following were the colours observed in the boric acid : borax buffers.

pH.	Colour.
9.24	green
8.2	green-blue
* 7.8	blue * (full day colour)
7.6	blue-violet
7.3	violet
7.09	red-violet
6.7	red-violet
6.0	magenta (bud-colour and faded corolla).

In M/10 HCl the colour was a bright cherry-red.

The plant under observation was growing in the fernery at the Royal Botanic Garden, Edinburgh. The house is kept

at a day temperature of about 21°C . to 26.7°C . The buds open in the early morning, expanding from the tightly-rolled magenta-pink (pH 6.0) to full blue (pH 7.8) in sixty to ninety minutes. If the sun is shining, the flowers may be over by mid-day, while on a dull day they may last till between 4 and 5 p.m. It was decided to examine the effect of light and temperature on the diurnal changes. To do this it was necessary to use cut flowers, but it was found that buds cut either the night before or at dawn and put in water in the fernery opened quite normally and behaved just like buds of the same day left on the vine. There was therefore no objection on those grounds to using cut flowers in the laboratory. For comparison, measurements were taken of a fully expanded flower, cut at 12.30 p.m. on a dull day, temperature 21°C . (colour pure blue).

Diameter of corolla	9.5 cm.
Length of tube to spring of petals	5.1 „
Diameter of tube	1.2 „
Distance between ribs at circumference	5.5 „

Effect of Light on opening of Buds. If buds due to open the next day (that is, showing a touch of colour between the ribs of the corolla) are cut and placed in darkness at 12 noon, at a temperature of 18.3°C ., they will be open by 9 a.m. next day. The following differences from the normal are seen:—size, less than normal; outline of corolla remains pentagonal, never becomes quite circular; the colour remains deep magenta.

Buds exposed to light from a 60-watt electric bulb, 3 p.m. to 9 a.m., temperature 18.3°C ., did not open. The ribs of the corolla unfurled slightly, but no more. The colour remained deep magenta, and the flower withered without opening.

Evidence that exposure to light in the bud influences flower-colour is given by the behaviour of a cluster of buds put to open in darkness. Each successive bud to open is redder in colour than the first, and smaller in size.

Effect of Temperature on opening of Buds.—The effect of different temperatures was tried on buds in darkness only. It was found that between 15° to 32°C . buds would open; above 32°C . the flowers withered in the bud. Increase of temperature increases the speed of the opening and withering;

the whole flowering period is over by 9 a.m. at 32 ° C. in darkness. It was found that a temperature of 21 ° C. was the optimum, judging by size of flower and colour of corolla. Even at this temperature the corolla never reached the pure blue of the illuminated flower; a deep violet-blue was the best.

It is evident, therefore, that the full development of the flower is conditioned by both light and temperature, light being the master-factor in determining the reaction of the cell-sap of the corolla and therefore the flower-colour.

The effect of carbon dioxide on the colour-change was also tested. It was found (by enclosing the flower in a large desiccator with soda lime, the desiccator being kept in the greenhouse beside the vine) that the colour-change takes place as usual in CO₂ free air. The colour-change is altered (in the acid direction) in atmosphere with excess CO₂. The flower was put in a small beaker of plain water standing in a desiccator with 500 c.c. of water charged under pressure with CO₂. Cut discs of the corolla are freely permeable to CO₂ over their whole surface, not only at the cut edges. When they are floated on water charged with CO₂ the colour rapidly changes from blue to pink. The CO₂ passes out freely when the discs are removed to plain water, where they quickly resume their original colour. It is therefore suggested that the increased acidity as the flower fades is not due to accumulated respiratory CO₂, but to alterations in the buffer-system of the cells. It has been noted by Irwin (5) that increased respiration in corollas of *Salvia* may be accompanied by decreased acidity, as judged by the colour of the flower.

It is obvious that the metabolic changes accompanying the rapid opening and fading of a flower are exceedingly complicated, and the study of the changing sap-reactions may cast light on some of the angles of the problem.

PRIMULA SINENSIS.

In turning to the colour varieties of *Primula sinensis* we are dealing with material whose hereditary equipment and genetic behaviour has been extensively studied. Gregory, de Winton, and Bateson (4) have given an account of some of the factors concerned with the production of colour in

the stigma, corolla, calyx, leaves, and stems. These include the following :—

G, giving green stigma ; g, red stigma.

B, blue colour ; b, red.

There is also the factor R, which with B gives magentas.

The flowers studied were "Reading Ruby" (deep magenta, BR), "The Czar" (dark blue, Br), "Etna" (dark red in flowers, stigma, leaves, and stems, bR), and "Light Blue Star." The first observations on these flowers were made in July 1928 at the John Innes Horticultural Institution, on plants from the late Mr. Gregory's strains, carried on by Miss de Winton. The experiments were carried on at University College, Dundee, during the seasons 1929 and 1930, at intervals from March to June. In this case the plants were seedlings from Messrs. Suttons' seeds, in their first year of growth. As the season progressed it was found that the "blue forms" became more purple than during the early months of the year. Whether increasing temperature or light is the cause of this has not yet been ascertained.

The method of extraction of pigment was the same as that used for *Ipomoea*, but because of the small size of the flowers it was necessary to use two corollas to 5 c.c. liquid. In addition to anthocyanins, these flowers contain quantities of flavones, especially in the tube and "eye" of the flower: only the expanded part of the corolla was used for extraction. In order to check the tints assumed by the pigments in different buffers, three sets were prepared :—Palitzsch (3), Clark & Lubs' acid potassium phosphate and sodium hydroxide, [range pH 5.8–8.0] (3), and the British Drug Houses Universal Buffer mixture, pH 2.8–7.2. The borate buffers were not of much use in this case, because the reactions of the flowers proved to lie well on the acid side of neutrality. The colours of the phosphate and the U.B.M. tubes agreed well; the latter gave a slightly better match with the flower-petal at the acid end of the scale. The corolla of Etna gave a reaction of approximately pH 3.1, of Reading Ruby about 4.0, and of Czar about 4.7.

Comparing the pigments of Etna and Czar, from pH 2.8 to pH 9.24, they appeared to be indistinguishable in tint in solutions of the same pH value. Reading Ruby gave a bluer tint over the significant part of the range.

It is suggested that the pigment of Etna and Czar is the same, and that the factor-difference between them (turning red into blue) is concerned with the reaction of the cell-sap; that is, with the buffer system of the cells. The same pigment in cell-sap of different reactions would show up as a different colour.

The behaviour of Reading Ruby suggests the presence of another anthocyanin along with that occurring in Etna and Czar. Reading Ruby also behaves as a dominant to Etna and Czar.

The pale colour of Light Blue Star made it difficult to prepare standards of a sufficiently deep tint to compare with Etna and Czar, but by diluting pigments from the latter flowers with the appropriate buffers the Light Blue Star could be matched. There again the colour was indistinguishable from those of Etna and Czar. Much flavone was present.

PAPAYER RHOEAS.

For details of the factorial situation in *Papaver Rhoeas*, see the paper by Newton (6). The plant provides a number of coloured strains, which can be arranged in the following epistatic series: crimson, scarlet, port, claret, mauve. Crimson is heterozygous, and single-factor differences exist between scarlet-port, port-claret, claret-mauve. When tested in buffers the scarlet-port pigments appeared the same. Much flavone is present, especially in black spot at base, which is better removed for test. There again a reaction-regulating function is suggested for a Mendelian factor.

It is natural that in breeding work, especially as methods grow more refined and tests more exacting, attention should be principally focussed on morphological expressions which it is possible to assess with considerable accuracy. The extensive work on inheritance of the more subtle physiological or metabolic characteristics in Maize needs to be extended to many other plants. The work of Small (9) and his co-workers on the hydron concentration of plant tissues might well be applied most profitably to plants of known genetic constitution and behaviour, and these observations on flower-colour and reaction extended. Many plants exist in which there are full- and pale-coloured, or blue, red and pink varieties; for

example, the Annual Convolvulus (*C. tricolor*), Corn-flower, not to mention Sweet Pea. The greenhouse *Cineraria* is in the act of producing a difficult and interesting problem. The majority of the current florists' strains show blue, violet, magenta, crimson, and rose shades, which might easily be referable to one type of anthocyanin pigment. Recently there have appeared on the market so-called scarlet (really brick-red) strains. The raiser of one of these strains has told the writer that the colour appeared spontaneously in a family of "pink shades." By selection the proportion of brick shades has been increased. The writer is attempting by strict isolation of plants of the brick-red strain to obtain a selfed progeny which will give at least an indication of the diversity of the strain. But the problem remains a chemical one—does the appearance of this new colour indicate a new chemical compound made by the plant (*i.e.* a brick instead of a rose-red anthocyanin): is it a question of sap reaction, or of a development of plastid pigment in addition to sap pigment? If the breeding experiments are successful, it may be possible to attempt an answer to some of these questions, but in the meantime they must be left unanswered.

SUMMARY.

1. The colour of the cell-sap in living cells of the following flowers, *Ipomoea Leerii*, *Primula sinensis*, *Papaver Rhoeas*, was compared with buffer standards prepared with the anthocyanins of the flowers themselves.

2. It was possible in this way to estimate the approximate pH value of the cell-sap corresponding to the colours shown by the flowers under various conditions.

3. *Ipomoea Leerii* has a diurnal colour-range from magenta-pink (bud) to full blue in the freshly-opened flower, corresponding to a pH range of 6–7.8. The development of the full blue is conditioned by both light and temperature. In the dark a violet (pH 7.09–pH 7.3) is the colour attained, between 15°–32° C. At a temperature below 15° C., in light, a similar colour is reached.

4. The commercial colour-varieties "Czar," "Etna," "Reading Ruby," "Light Blue Star" of *Primula sinensis* were examined. The cell-sap of Etna was the most acid (about

pH 3.1), Reading Ruby about 4.0, and Czar about 4.7. The pH value of the Light Blue Star was not determined. The colours obtained from the corollas of Etna and Czar, at the same pH. values in the same buffers, were indistinguishable. It is suggested that the genetic factorial difference between these two flower-colours is one affecting the reaction of the cell-sap of the corolla and possibly of the whole plant.

5. In *Papaver Rhoeas* the two colours "scarlet" and "port" also gave similar tints at the same pH value of the same buffers.

6. The application of this method of investigation to other families where similar colour varieties exist is suggested.

REFERENCES.

- (1) BOYLE, R. (see ONSLOW).
- (2) BUXTON, B. H., and DARBISHIRE, F. V.: The pH Value of the Cell-sap of Flowers. Journ. Roy. Hort. Soc., lii (1927), 46.
- (3) CLARK, W. MANSFIELD: Determination of Hydrogen Ions. Second Ed. (1922).
- (4) GREGORY, R. P., DE WINTON, D., and BATESON, W.: Genetics of *Primula sinensis*. Journ. of Genetics, xiii, No. 2, 129.
- (5) IRWIN, M.: Comparative Studies on Respiration, vi: Increased Production of Carbon Dioxide accompanied by Decreased Acidity. Journ. Gen. Physiol., i, No. 4 (1919), 399.
- (6) NEWTON, W. C. F.: Inheritance of Flower Colour in *Papaver Rhoeas* and Related Forms. Journ. of Genetics, xxi, No. 3 (1929), 389.
- (7) ONSLOW, MURIEL WHELDALE: Anthocyanin Pigments of Plants. Second Ed.
- (8) PANTIN, C. F. A.: Determination of the pH of Microscopic Bodies. Nature, cxi (1923), 81.
- (9) SMALL, J.: Hydrogen-ion Concentration in Plant Cells and Tissues. Protoplasma-Monographien, Bd. ii (1929), Berlin.

NOTES ON GALLOWAY ROSES. By J. R. MATTHEWS, M.A.

(Read 19th June 1930.)

Due largely to the work of M'Andrew, Druce, and others, the flora of Galloway may be regarded as now fairly well known. It will always remain an interesting part of the Scottish flora by reason of its peculiar composition, including as it does a considerable proportion of the "Southern Element" of the British flora which finds its way into Scotland. Several lists for the area have been published, and these have been consulted in drawing up the following notes on the roses of the district. Most of the records, however, are based on my own gatherings made during a short visit last August. The rose flora is not abundant, nor are the species widely distributed. In Wigtownshire they are most frequent in the Machars or low-lying cultivated plains in the south, and except in the sheltered valleys are absent from the moors lying on the north side of the county. Throughout the county as a whole there is evidence, as elsewhere in Scotland, that the relative infrequency of roses as members of the native flora is not unconnected with the development of the modern highway, broader roads replacing the former narrow lanes where roses often abounded.

Unless otherwise stated, the records which follow refer to Wigtownshire, v.-c. 74, and many are additional to the vice-comital distribution given by Col. Wolley-Dod in his Revised Arrangement of British Roses. The names used are those of the London Catalogue, Edit. 11.

R. SPINOSISSIMA Linn.

Both var. *typica* W.-Dod, with glandular hispid peduncles, and var. *pimpinellifolia* (Linn.), with smooth peduncles, are frequent in suitable coastal habitats. The former occurs at Port William, Terally Point, and Port Logan; the latter is abundant at New England Bay, Torrs Warren, and elsewhere on Luce Bay. Both occur also in inland stations along the Water of Luce and on the roadside between Glenluce and

Carscreugh Castle. The length and hispidity of the peduncles vary considerably, the peduncle frequently being hispid only at the base. Examination of a large series of specimens shows a tendency in some to glandular petioles and midribs, thus approaching var. *Ripartii* (Déségl.), but the leaflets are not glandular-biserrate as in that variety. In some specimens the midribs are sparsely pilose.

× *R. SABINI* Woods.

A single bush in Grennan Plantation, two miles north of Drummore, agrees closely with the descriptions of this, one of the assemblage of hybrids now grouped under *spinosissimae* × *villosae*. From the characters of the plant itself and the presence of *R. omissa* Déségl. in close proximity to the hybrid, the evidence is in favour of regarding this species as the second parent. *R. Sabini* is recorded also from Monreith by Druce.

R. CANINA Linn.

var. *lutetiana* Baker. This is the commonest variety of the aggregate *R. canina* Linn. Although Col. Wolley-Dod gives no records for Scotland, it is certainly not rare north of the border. Localities in Wigtownshire are Grennan Plantation, Glenluce Abbey, and near Bargrennan; also Cree Bridge, Larg, and Blackcraig in Kirkcudbrightshire, v.-c. 73.

var. *separabilis* (Déségl.). A single plant near Glenluce Abbey with fairly large, elongate obovoid fruit seems referable to this variety.

var. *flexibilis* (Déségl.). This does not differ much from var. *lutetiana*. A plant near Grennan Plantation approaches Déséglise's description except in the shape of the leaflets, which are acute, not rounded at the apex. Wolley-Dod refers to the same feature in specimens examined by him and states that the variety is not represented typically in Britain.

var. *senticosa* Baker. Near Benfield between Newton Stewart and Glenluce.

var. *insignis* (Déségl. & Rip.). This is the commonest variety, having irregularly serrate leaflets, showing the transition between the *Lutetianae* and *Dumales* groups. Frequent between Glenluce and New Luce, Benfield, and Grennan Plantation; also between Cree Bridge and Larg, v.-c. 73.

var. *globularis* (Franch.). Specimens collected near Glen-

luce Abbey agree well with the original description and with Déséglise's notes on this variety.

var. *syntrichostyla* (Rip.). A single specimen collected at the railway bridge near Bishop Burn between Newton Stewart and Wigtown.

var. *dumalis* Bechst. The common *canina* form with fully biserrate leaflets. Glenluce, Glenluce Abbey, and New Luce; also between Cree Bridge and Larg, v.-c. 73.

var. *biserrata* (Mér.). Glenluce and Dunragit.

var. *recognita* Rouy. One specimen collected at Grennan Plantation comes near this variety.

R. DUMETORUM Thuill.

Druce records *R. dumetorum* from Wigtown. As an aggregate the species is much less frequent than the aggregate *R. canina*, and I have no gatherings of var. *typica* W.-Dod. The following varieties occur:—

var. *urbica* Baker. Grennan Plantation; and between Cree Bridge and Larg, v.-c. 73. Druce records this variety from Penninghame.

var. *jactata* (Déségl.). Near Newton Stewart railway station; and several plants between Cree Bridge and Larg, v.-c. 73.

var. *Gabrielis* R. Kell. Between Cree Bridge and Larg, v.-c. 73.

R. GLAUCA Vill.

This species is not uncommon in the district but its distribution is apparently local.

var. *Reuteri* (God.). Several bushes near Benfield. The serration of the leaflets varies, being occasionally irregularly serrate, thus showing a transition to var. *subcristata* Baker. There is little doubt that a more intensive study of the forms of *R. glauca* and *R. coriifolia*, which are essentially northern species, would prove that they could be further segregated, perhaps along the lines followed for *R. canina* and *R. dumetorum*.

var. *subcristata* (Baker). This is the common variety of *R. glauca*. Frequent at railway bridge near Bishop Burn, near Benfield, and along the New Luce road.

var. *stephanocarpa* (Déségl. & Rip.). Collected in one

locality only about three miles west of Newton Stewart on the Glenluce road. The glandular development on the leaflets varies considerably but is sufficiently pronounced to justify the inclusion of this variety in the list.

var. *subcanina* Chr. Forms of *R. glauca* with reflexed sepals, which may be placed under this name, undoubtedly occur in Scotland, although Wolley-Dod does not include it in his account of the Roses of Britain. The variety is reported from Drummore by Druce.

R. CORIIFOLIA Fries.

This aggregate species, so far as I know, has not hitherto been recorded for Wigtownshire, and is apparently very rare.

var. *obovata* (Baker). Near Bargrennan. Undoubtedly one of the Subcoriifoliae group, the sepals reflexed after flowering.

R. MOLLIS Sm.

In considerable abundance on the roadside about midway between Newton Stewart and Glenluce. The presence of sub-foliar glands refers the specimen to var. *glandulosa* W.-Dod, but my experience of *R. mollis* in Scotland inclines me to the view that glandularity in this species is of little taxonomic value. Also near Queen Mary's Bridge, Minnigaff, v.-c. 73. Druce records var. *coerulea* Baker from Port Logan. For recent views regarding the classification of the forms of this and other northern species see Heslop Harrison.

R. OMISSA Déségl.

The numerous so-called varieties of this are difficult to distinguish and a new arrangement has been suggested by Heslop Harrison.

var. *typica* R. Kell. and forma *resinosoides* (Crép.) occur near New Luce and at Grennan Plantation; also near Larg, v.-c. 73. Recorded from Drummore by Druce.

var. *Sherardi* (Davies). New Luce.

var. *submollis* (Ley). Grennan Plantation and between Cree Bridge and Larg, v.-c. 73.

var. *pseudo-mollis* E. G. Baker. Near railway station between Newton Stewart and Wigtown.

var. *Woodsiana* (Groves). Near Glenluce, one gathering.

var. *suberecta* (Ley). This is the commonest variety of the *omissa* aggregate. Glenluce, Grennan Plantation, Benfield. Also near Larg, v.-c. 73. Recorded from Dunragit by Druce.

var. *cinerascens* (Dum.). A single bush near Grennan Plantation agrees fairly closely with the technical characters ascribed to this variety, although the leaflets are not perfectly uniserrate.

R. TOMENTOSA Sm.

I have no gathering of this, which I believe to be a comparatively rare species in Scotland, most northern so-called *tomenosa* forms being referable to the *omissa* group. It is recorded from Penninghame (Druce) and from Newton Stewart (Bailey).

R. RUBIGINOSA Linn.

This and its variety *apricorum* (Rip.) are recorded by Druce, who regards the species as native in Galloway.

REFERENCES.

- DRUCE (1883): List of Wigtownshire Plants. Bot. Record Club.
 — (1899): Notes on the Flora of Wigtownshire. Ann. Scot. Nat. Hist.
 — (1910): Plants of some Southern Scottish Counties. *Ibid.*
 — (1911): Scottish Plants, chiefly from Skye, Peebles, Selkirk, and Kirkeudbright. *Ibid.*
 HESLOP HARRISON (1930): A Revision of Certain Northern Rose Groups. The Naturalist.
 M'ANDREW (1882): A List of Flowering Plants of Dumfriesshire and Kirkeudbrightshire. Trans. Dumf. & Gall. Nat. Hist. Soc.
 — (1895): A List of Wigtownshire Plants. *Ibid.*
 SCOTT-ELLIOT (1896): Flora of Dumfriesshire.
 WOLLEY-DOD (1920): A Revised Arrangement of British Roses. Journ. Bot. Suppl.
 — (1924): The Roses of Britain. London.

A NOTE ON A RARE PARASITIC FUNGUS ON MYRICA GALE L.—
OVULARIA DESTRUCTIVA (PHIL. & PLOW.) MASSEE.

By C. E. FOISTER, B.A.

(Read 19th June 1930.)

Specimens of the bog myrtle, *Myrica Gale L.*, were collected at Garelochhead in May by Mrs. N. L. Alcock, and some were found to be affected with a disease which involved the ends of twigs only. These were covered with a thick, greyish-white band, varying from 0.5 cm. to 1.5 cm. in width. The band was found to consist of the fructifications of a fungus, the mycelium of which permeated the bark and vascular tissues in particular. The effect of the attack was a stunting of the twigs. The presence of the causal fungus on the twigs has not been recorded before in Scotland, and it was thought desirable to record this rare occurrence.

The causal fungus, *Ovularia destructiva* (Phil. & Plow.) Massee, forms stromatic cushions under the bark which ultimately burst through, and because these stroma are so closely produced, a band of uniform appearance is the result. Upon the stroma unbranched, fertile hyphae bear oval or elliptical, hyaline, one-celled spores, which average $21.5 \times 10.6 \mu$, with a range in measurement of $18.3\text{--}24.3 \times 7.5\text{--}13.5 \mu$. On identifying this fungus as a species of *Ovularia*, comparison was made with a fungus on the leaves of *Myrica Gale* collected by Dr. M. Wilson. The latter fungus causes brown spots on the upper side of the leaves, while on the under side of the leaves, in the same area as the brown spot, a white web of the mycelium of the fungus is produced. Spores of the latter fungus measured $21.2 \times 9.9 \mu$ and were apparently identical in this respect and other characteristics with the fungus on the twigs. While the specimens were kept under examination in a damp chamber, the fungus spread to the leaves and produced on them brown spots similar to those found on the leaves collected by Dr. Wilson.

Ovularia destructiva was first recorded at North Wootton, Lincs., by Phillips and Plowright in 1877, but they named it *Ramularia destructiva*; they recorded it on both leaves and

twigs. Since then the fungus has not been recorded on the twigs in England, and in any case, its record on the twigs in Scotland is believed to be new. In 1885 Ellis and Martin found the same fungus in America, but named it *Ovularia monilioides*; while Peck in Germany recorded it as *Ovularia myricae*. In 1886 Eichelbaum collected it in Hamburg, naming it *Sphaeria Sommeri*; and Saccardo listed it more correctly as *Ovularia Sommeri* (Eichelbaum). It has also been found in Belgium, Holland, Sweden, and Denmark; in the last-mentioned country Lind states that the fungus is very common all the year round. Lind was also the first to correctly and fully name the fungus as *Ovularia destructiva* (Phil. & Plow.) Massee. Vestergren states that the fungus hibernates on the twigs and buds. The damage is not usually severe, stunting being the chief effect.

REFERENCES.

- PHILLIPS, W., and PLOWRIGHT, C. B.: *Grevillea*, vi (1877), p. 22.
 ELLIS and MARTIN: *American Naturalist* (1885), p. 76.
 SACCARDO, P. A.: *Sylloge Fungorum*, iv. (1886), pp. 145 and 198.
 EICHELBAUM: *Bot. Centralb.*, xxix (1887), p. 378.
 SACCARDO, P. A.: *Grevillea*, xxi (1893), p. 68: *Syl. Fun.*, xi (1895), p. 599.
 MASSEE, G.: *British Fungus Flora*, iii (1893), p. 320.
 VESTERGREN: *Bot. Notis.* (1900), p. 35.
 LINDAU, G.: *Rabenhorst's Krypt. Flora*, viii (1907), pp. 235-237.
 LIND, J.: *Rostrup's Danish Fungi* (1913), p. 498.
 OUDEMANS, C. A. J. A.: *Enumeratio System. Fung.*, ii (1920), pp. 285-286.

THE SCOTTISH ALPINE BOTANICAL CLUB EXCURSION, 1928.

By ROBERT MOYES ADAM. (With Pl. XVI.)

(Road 16th October 1930.)

On the evening of 23rd July the members assembled for their annual excursion at the Invercauld Arms Hotel, Braemar.

The following morning plans were made to examine the region of Little Craigandal and, if the weather proved favourable, to include the massif of Beinn a' Bhuird.

Accordingly, starting out from Braemar by the aid of a horse-gig, the party forded the Dee and reached the grounds of Invercauld, and thereafter proceeded through a forest of Pines as far as vehicular traffic was possible. This brought them to the course of the Sluggan burn, along which a pony-track supplied comparatively easy access to the higher peaks of the Cairngorms. They had purposed at first to confine their attention to Little Craigandal, from which less common Alpines had been reported in 1889 ; but, as the party were in good heart and the prospect was pleasing, they decided to venture farther and attempt Beinn a' Bhuird, on which immense snow-fields still remained.

Making their way thither, and keeping the Quoich water on their left, they soon gained evidence of their rapid ascent in the gathering of *Cornus suecica* L. in flower, and *Betula nana* L. in full leaf. A steady pull to the point where a smaller stream from the base of Beinn A'an joined the Quoich brought them into full view of their objective ; and heading southward over a rough surface bestrewn with *Vaccinium uliginosum* L., they obtained an extensive view of the Dee valley and the mountains to the south and west, of which Lochnagar was the outstanding feature. Visibility being at its best, the contour and colour of that attractive hilltop were seen to perfection.

At something over 2500 feet the moorland became carpeted with Mountain Azalea (*Azalea procumbens* L.), the flowering plants spreading through the herbage, which extended to the barricade of boulders blocking the mouth of the corrie. Going thereafter proved dangerous and exhausting, as only over such improvised stepping-stones could further progress be

made : and the loss of time thereby incurred dissuaded the party from ascending the summit, which to all seeming was bare and uninviting, contenting themselves with searching the screes to the north of Dubh Lochan.

Beinn a' Bhuid, the Table Mountain, is so called, according to a modern writer who has made the range of the Cairngorms his peculiar study, "because the hilltop and its surrounding plateau seem literally flat as a table when viewed from the west." To those approaching it from an opposite direction its flatness did not appear ; nor did it prove to possess a flora as varied as others of the same group. Runnels and rock- ledges being anything but plentiful, the chances of the botanists were inevitably lessened ; and to add to their difficulties on the present occasion, vegetation was backward and bog-plants hard to distinguish. In this connection it may be of service to put on record that rare Sedges were few and undeveloped, and Alpine Rushes scarce. Search was made for *Saxifraga rivularis* L., reported in 1889 "from the spot where Professor Balfour found it many years ago," but without success. Of plants peculiar to these mountains the Crowfoot (*Ranunculus acris* var. *pumilus* Wahl.) raised its golden cup from swampy patches beneath the screes, its bluntly cut and shining leaves affording it, though lowly, an air of distinction. The common Birch (*Betula alba* L.), which ascended the Sluggan burn to about 2000 feet, bore traces in its cropped and blasted growth of the depredations of Deer and the force of the storms to which it was exposed. In the corrie Stags were viewed at close quarters ; but throughout the day Red Grouse were not once flushed.

It was after six o'clock when the party began their journey homeward ; and though they availed themselves of the bridle-path all the way down, they did not reach Braemar till after sundown. It has to be explained meanwhile that considerable time was occupied in fording the Dee below Invercauld, an operation which tried to the utmost the jaded botanists, who to maintain a show of fitness on their arrival were not above availing themselves of a passing bus for the last mile and a half ! Laborious and long as had been their undertaking, they were able ere retiring to make up the following summary of the day's gatherings, namely : *Thalictrum alpinum* L., *Ranunculus acris* var. *pumilus* Wahl., *Caltha radicans* Forst., *Trollius*

europaeus L., *Cochlearia alpina* Wats., *Silene acaulis* L., *Lychnis dioica* Mill. (at 3000 feet), *Cerastium alpinum* L., *Genista anglica* L., *Rubus saxatilis* L., *R. Chamaemorus* L., *Potentilla Crantzii* G. Beck, *P. Sibbaldi* Hall f., *Saxifraga stellaris* L., *Sedum roseum* Scop., *Epilobium alsinefolium* Vill., *E. alpinum* Huds., *Angelica sylvestris* L., *Cornus suecica* L., *Gnaphalium supinum* L., *Vaccinium uliginosum* L. (marked features of Corrie), *Arctostaphylos Uva-ursi* Spreng., *Azalea procumbens* L., *Pyrola media* Sw., *Trientalis europaea* L. (at 2300 feet), *Veronica alpina* L., *Melampyrum pratense* var. *montanum* Johnst., *Oxyria digyna* Hill, *Betula nana* L., *Salix repens* L., *S. herbacea* L., *Narthecium ossifragum* Huds., *Tofieldia palustris* Huds., *Juncus trifidus* L., *Carex pulicaris* L., *C. canescens* Lightf., *C. rigida* Good., *C. pilulifera* L., *Juniperus communis* L., *Cryptogramme crispa* Br., *Lastraea dilatata* Presl, *Lycopodium Selago* L., *L. annotinum* L., *L. clavatum* L., *L. alpinum* L.

Following the lead of members at their meeting in 1889, the Club devoted Wednesday, 25th July, to an excursion to Loch Kander, on the borders of Angus and Aberdeenshire. The day proved gusty, but not unfavourable for a tramp amid romantic scenery.

Availing themselves of means of locomotion provided by the hotel, they drove up Glen Clunie, and, turning to the left three miles out, they reached Loch Callater, along whose shores lay possible tracks in the direction of the more remote district which was the object of their quest. Both of these were found helpful, but that on the south side gave easier access to the Corrie, though it had to be abandoned as soon as the Loch was left behind. The country transversed thereafter abounded in heather, and its undergrowth was plentifully interspersed with Cloudberry and Orchis.

On gaining the higher level behind which lay Loch Kander, bare of vegetation on its margin and swept by fierce gusts from the gullies which flanked the overhanging cliffs, none could fail to be impressed with the majesty of the scene.

There being very little of botanical interest in the immediate vicinity of the Loch, it was decided to scale the heights of Coire Ceann Mor and Carn an Tuirc, from which such rarities as *Salix Sadleri* and *Carex frigida* had been reported. Three independent routes were selected, and much scrambling called



Corrie Dubh and Corrie nan Clach, eastern face of Benin a' Bhuid,
3924 feet.



Corrie Ceann Mor, Glen Callater, showing steep rocks descending on the
north face of Cairn na Glasba, 3484 feet, to Loch Kander.

for, yet with rather meagre gleanings, the less common Sedges in particular being scarce. As on the previous day, vegetation was found to be backward, many of the true Alpines being only in flower. Another incident, which may account for their apparent infrequency in that particular area, was the discovery of sixty head of goats, of comparatively recent introduction, browsing on precipitous ledges, where sheep and deer do not naturally venture. Yet, in spite of untoward circumstances, a goodly collection of plants was made, and an enjoyable day spent amidst nature's solitude and grandeur, occasional showers and squalls only deepening the impression.

A leisurely walk by the same route followed earlier in the day brought the united party to the northern end of Loch Callater, where a motor-car awaited their return.

Among the specimens secured the following may be named : *Thalictrum alpinum* L., *Ranunculus reptans* L., *Caltha palustris* L., *Cochlearia alpina* Wats., *Silene acaulis* L., *Cerastium alpinum* L., *Geranium sylvaticum* L., *Rubus Chamaemorus* L., *Saxifraga aizoides* L., *S. oppositifolia* L., *S. stellaris* L., *S. hypnoides* L., *Parnassia palustris* L., *Sedum roseum* Scop., *Epilobium alsinefolium* Vill., *E. alpinum* Huds., *Angelica sylvestris* L., *Galium boreale* L., *Gnaphalium supinum* L., *Vaccinium uliginosum* L., *Trientalis europaea* L., *Menyanthes trifoliata* L., *Veronica humifusa* Dicks., *Melampyrum pratense* var. *montanum* Johnst., *Littorella lacustris* L., *Polygonum viviparum* L., *Salix lapponum* L., *S. myrsinites* L., *S. herbacea* L., *S. reticulata* L., *Tofieldia palustris* Huds., *Juncus trifidus* L., *J. supinus* Moench., *J. triglumis* L., *Carex pulicaris* L., *C. atrata* L., *C. rigida* Good., *C. capillaris* L., *C. inflata* Huds., *Alopecurus alpinus* Sm., *Phleum alpinum* L., *Briza media* L., *Poa alpina* L., *Cryptogramme crispa* Br., *Athyrium alpestre* Milde, *Botrychium Lunaria* Sw., *Lycopodium Selago* L., *L. alpinum* L., *L. clavatum* L., *Selaginella selaginoides* Gray.

THE SCOTTISH ALPINE BOTANICAL CLUB EXCURSION, 1929.

By ROBERT MOYES ADAM. (With Pl. XVII.)

(Read 16th October 1930.)

In the evening of 15th July the members of the Club assembled in the dining-room at the Spittal of Glenshee Hotel. The number was fewer than usual. The date of the meeting was shadowed by the death of the oldest member, the Very Rev. Dr. David Paul, and to whom earlier in the day the President and Vice-President had paid their last tribute at the graveside in Edinburgh. It seemed strange to hold the meeting without the veteran, for no more enthusiastic and regular attender at the Annual Excursion had the Club. The Scottish Alpine Flora was near to his heart, and to carry through the arranged programme seemed not unfitting and appropriate.

In the course of a stroll after dinner along the entrance to Glen Lochy members admired the abundance of *Helianthemum Chamaecistus* in excellent state.

Tuesday, 16th July, was devoted to a visitation of the gardens at Balmoral and Glassel House in Deeside. Transport facilities were generously provided by one of the members, and the journey made by the Devil's Elbow and Cairnwell Pass *via* Braemar. This highway afforded a striking example of the improved Highland road. In former times the narrowness, frequent dangerous bends, made the driver's task hazardous—now a new danger has arisen in the frequency and number of vehicles which travel north and south over this roadway. In the course of the Club's run the dryness of the hill slopes was everywhere in evidence. Watercourses were either dry or holding mere trickles. Rainfall over this area had been negligible for months and constituted one of the driest periods on record. A halt was made for a short space in the Scots Pine forest beyond Invercauld where it was believed *Linnaea borealis* might be observed. The search proved unsuccessful, and punctually at noon the party arrived at the Crathie entrance to Balmoral Castle. After receiving directions at the gate, a slow pace for a few hundred yards along the drive brought the party to the residence of the King's Com

missioner—Major Mackenzie, M.V.O. Thereafter in company with him the nursery was visited, and several interesting exotics were observed in seedling stage. The President noted among them familiar Asiatic species. From the nursery the party proceeded by car to the environs of the Castle, the route followed leading through an avenue of stately Conifers which had been planted and directed in the life of the late Prince Consort some seventy years ago. The sunk garden on the west side of the Castle was visited. It is of recent construction and occupies an area about 600 yards square and is sunk about 4 feet below the general level of the terrace. The garden is walled with granite blocks, which are built so as to provide ledges and crannies for rock-loving plants. On the extreme margin of the Castle lawn to the south is another garden. The design has been cunningly conceived, for the observer who surveys the lawn from the Castle detects no sign of this delightful addition to Balmoral gardens. On a near approach the site and design appear. The whole takes the form of a crescent, with two terraces at different levels, each supported by a wall to face south, over which rock-plants spread or hang from every point. The design is intersected by a paved pathway and steps which connect the different levels. On the boundary next the Forest is a novel hedge of Poplar. A dense herbaceous border flanks the garden on the west. Among the flowers noted, the colours of mauve and yellow strike a dominant note, and the Club was informed that they are among the favourites of their Majesties. It was also pointed out that every effort is made to grow plants which afford a bright display in autumn—the usual time when Royalty are in residence. The Castle gardens are 1100 feet above sea-level, and suffer frequently from frost in every month of the year. The tour of inspection was completed by observing the show of dwarf Rhododendrons which grow near the Commissioner's residence.

After thanking Major Mackenzie for his kindness and courtesy the party left by the Abergeldie road, proceeding *via* Knock and the south side of the Dee, to miss Ballater, and on where the river was crossed at Aboyne. The main Deeside highway was now joined, and thence by Kincardine O'Neil to Torphins, Glassel House was reached shortly after 4 p.m. On the arrival of the party, Mr. Wood, the owner, was found busy

among his plants in the garden, but on hearing that the Club had come, hastened to welcome them.

The Glassel rock garden was found to be of exceptional interest. Most of the design has been fashioned out of a natural rocky declivity which lay south of the mansion, the whole descending sharply towards the Canny burn, a tributary of the Dee. The work of forming the garden has been largely due to the enthusiasm of the owner, who has spared neither time nor expense to perfect his plan. Water is led on to the upper levels, and by an ingenious system of miniature rills and rivulets—which in places link up rock basins, providing a perfect system of habitats, all of which have been used to the best advantage by the gardener. Over all this wonderful rock-work appropriate stone steps are here and there placed so that every point is accessible, while the specimens observed in cultivation were outstanding in their health and vigour. Mr. Wood also gave an exhibition of his Apiary and the appliances employed, and a hut erected for the purpose of instructional courses directed by himself. The afternoon was found to be all too short for the amount to be seen, and about 7.30 the Club had reluctantly to depart after cordially thanking him for his kindness and hospitality. The return journey was made *via* the Moor of Dinnet, where the whole scene was ablaze with the purple of *Erica cinerea*, and then through the Birch forests and the Pass of Ballater to Braemar, and thanks to a careful and efficient chauffeur, Glen Shee was reached at 8.30 p.m.

For the Wednesday the Mecca fixed for the Club's activities was the famous corries in Canlochan Glen, and more particularly the rocky slopes which descend in the east from Glas Maol. Again, as on the previous day, a conveyance to assist the party was provided by the Vice-President. It was shortly after 9 a.m. when the hotel was left behind, and, proceeding by the highway in Glen Beg to a point near Ruidh Dorch, a pause was made to inspect an unusually fine patch of *Mimulus Langsdorffii*. The form was noted to be unlike the ordinary form, having remarkable spotting on the corolla. Joining the car, no further stop was made until the pass was reached, and a few yards beyond the summit the excursion party bade farewell to the Vice-President and his car, and, turning to the right, commenced the gradual ascent towards the county

march fence—a very valuable land guide, incidentally separating the counties of Aberdeen and Perth. Meall Odhar, 3059 feet, is the first summit gained by following the boundary fence, but with a start at the road of 2250 feet, the ascent seemed easy to conquer. Outstanding of the plants were the numbers of *Azalea procumbens* flowering near the top and in a situation where wind action was much in evidence, most of the heath forming low-stunted growth. A dip of a few hundred feet and we were at the base of the gentle slope which in places forms long screes of dry rock and ultimately reaches the broad summit of Glas Maol. Before commencing the ascent several boggy pools were examined, and from several flushes the first real contact with Arctic Alpines was made.

The ascent of Glas Maol was made in zigzag fashion, and in due course the broad top was reached without any remarkable find. The whole summit region is covered with a carpet of vegetation among which *Carex rigida* is dominant. Near to the top also three county boundaries intersect—Perth, Aberdeen, and Forfar.

From the cairn, proceeding in an easterly direction, a descent of 200 feet brought the party to the old and historic track which the weary foot-traveller must use when crossing from Deeside to Glen Isla. The path is the highest of its kind in Scotland, and at the point where it skirts the Canlochan cliffs is 3300 feet above sea-level. Unfortunately this elevated viewpoint did not yield the prospect which in clear weather is impressive. A marked heat haze hung heavily over the great hollow of Canlochan. The Club, however, were in some measure compensated by the fine view of a Golden Eagle as it sailed out from the rocks below, and after a few wide sweeps disappeared into the haze. The botanical investigation began by an approach and descent of the great gully which is drained by a stream at the S.W. of the corrie, and in the course of the preliminary searches proved to be most productive. In a short space a dozen gems of Arctic Alpine fame were seen and a few collected. Outstanding were the masses of *Saxifraga hypnoides* in the most wonderful flower. Near the springs from which the stream was fed *Phleum alpinum* was abundant. *Saxifraga nivalis* was numerous and in flower. On one buttress were beautiful mats of *Dryas*, and a careful hunt alongside revealed numerous plants of that charming Alpine

Gentiana nivalis. Occurring frequently too on the scree were plants of *Veronica saxatilis*, and after raking over the highest position of one of the many stone shoots, a solitary plant of *Thlaspi alpestre* in fruit was picked. Over the dry ledges and cracks occurred many plants of *Erigeron borealis* in beautiful flower. *Saussurea alpina* was abundant but not yet in flower. The rocks were found to hold an infinite variety of habitats, and, in spite of the long period of drought, had very wet ledges where *Carex* dominated and odd plants of *Lychnis dioica* added a splash of colour. Of the Willows, *Salix lapponum* was the most abundant, and in the cooler recesses was very beautiful and in full flower—catkins very numerous. In spite of the riches which the corrie held, one plant failed to reveal itself—*Lactuca alpina*—but as there are many inaccessible ledges abundantly supplied with the conditions favourable to this plant, it may still hold out in this, one of the few localities where the plant has been found. The Club members spent several hours on the rocks and examined with some thoroughness the Glas Maol side, and it was about 6.30 p.m. when the members reassembled at the top of the gully where the first descent of the day had been made.

After exchanging notes on the finds of the day, the party started for home. The route followed was by the S.E. shoulder of Glas Maol, so as to omit the summit, and a diagonal descent towards the col and Meall Odhar, striking at this point a marked track which follows more or less the boundary fence. Holding to this route the road was reached in quick time, and the final stages of the journey were completed by resort to the hotel car, thus bringing to a close a remarkable day.

On 18th July two remaining members carried through a short excursion up Glen Beg and botanised part of the route to Glas Maol. A flying visit to the high tableland the same afternoon by one member, in the hope of collecting *Carex Watsoni*, failed owing to dense mist enveloping the regions about 3000 feet, and after spending some three hours he had to abandon the search. A few plants were added to the list, and the following are the most interesting specimens seen: *Thalictrum alpinum* L., *Trollius europaeus* L., *Cochlearia alpina* Wats., *Thlaspi alpestre* L., *Silene acaulis* L., *Lychnis dioica* Mill., *Cerastium alpinum* L., *Stellaria uliginosa* Murr., *Sagina Linnaei* Presl, *Linum catharticum* L., *Rubus saxatilis*



Eastern cliffs of Glas Mòr descending to Cailochan Glen, showing big gully at its south-western end

L., *R. Chamaemorus* L., *Dryas octopetala* L., *Geum rivale* L., *Potentilla Crantzii* G. Beck, *P. Sibbaldi* Hall. f., *Alchemilla alpestris* Schmidt, *A. alpina* L., *Saxifraga oppositifolia* L., *S. nivalis* L., *S. stellaris* L., *S. aizoides* L., *S. hypnoides* L., *Chrysosplenium oppositifolium* L., *C. alternifolium* L., *Par-nassia palustris* L., *Epilobium angustifolium* L., *E. alsine-folium* Vill., *E. alpinum* Huds., *E. anagallidifolium* Lam., *Angelica sylvestris* L., *Galium boreale* L., *G. saxatile* L., *Erigeron borealis* Vierh., *Solidago Virgaurea* var. *cambrica* (Huds.), *Gnaphalium supinum* L., *Cnicus heterophyllus* Willd., *Saussurea alpina* DC., *Vaccinium Vitis-Idaea* L., *V. uliginosum* L., *Pyrola secunda* L., *Lysimachia nemorum* L., *Trientalis europaea* L., *Gentiana nivalis* L., *Mimulus Langsdorffii* Donn, *Veronica alpina* L., *V. humifusa* Dicks., *V. saxatilis* L., *Rhinanthus Drummond-Hayi* Druce, *Melampyrum pratense* var. *montanum* Johnst., *Polygonum viviparum* L., *Oxyria digyna* Hill, *Salix lapponum* L., *S. myrsinites* L., *S. herbacea* L., *Habenaria viridis* Br., *Tofieldia palustris* Huds., *Juncus castaneus* Sm., *J. triglumis* L., *Luzula spicata* DC., *Carex pulicaris* L., *C. canescens* Lightf., *C. rigida* Good., *C. atrata* L., *C. Oederi* Retz., *C. capillaris* L., *C. vaginata* Tausch, *Alopecurus alpinus* Sm., *Phleum alpinum* L., *Asplenium viride* Huds., *Athyrium alpestre* Milde, *Polystichum Lonchitis* Roth, *Phegopteris polypodioides* Fée, *P. Dryopteris* Fée, *Botrychium Lunaria* Sw., *Lycopodium Selago* L., *L. alpinum* L., *Selaginella selaginoides* Gray.



“White Tip” Leeks showing collapse, loss of colour, and the large space between rows



Leek leaves affected with “White Tip” Disease. The large central leaf shows a water-logged area, and to its right is a marginal infection.

(Reproduced by courtesy of the Gardeners' Chronicle.)

TRANSACTIONS
OF THE
BOTANICAL SOCIETY OF EDINBURGH

SESSION XCV

THE WHITE TIP DISEASE OF LEEKS AND ITS CAUSAL
FUNGUS, PHYTOPHTHORA PORRI n. sp. By C. E.
FOISTER, B.A., Ph.D. (With Pl. XVIII.)

(Read 18th December 1930.)

A disease of Leeks, called by the growers "White Tip," has become of considerable importance in the last five or so years. It has probably been in existence for a long time, but has only recently become of serious importance. In September 1928 trials were initiated in Midlothian for the control of Downy Mildew of Leeks (*Peronospora Schleideni*), and what was supposed to be this disease was already appearing in plots adjoining the trial plots. White Tip symptoms were supposed to be an unusual manifestation of the Downy Mildew, although not at all like the usual symptoms of the disease. On examination this proved a wrong supposition, and eventually the cause of the White Tip symptoms was identified as a species of *Phytophthora*. There are no records of the approximate date when this disease was first noted. Growers have a varied experience of it, and some report that it has appeared in the last ten years, while others say that it was known in the previous generation, if not two generations ago. It has apparently been lying dormant for years, and has become epidemic owing to the influence of

unknown factors. It has spread considerably in the three years that the writer has had it under observation, and is present generally in the Lothians down to the Borders. It has been noticed in England before, but was associated with Downy Mildew; it was only after a warning note was published (8) that the Leeks were examined and the same *Phytophthora* found. It is recorded (14) as severe at Cheltenham and round Bristol, and is probably present elsewhere. It has not been found yet out of Great Britain.

PATHOLOGY.

The symptoms in sequence are the yellowing and dying of the tips of leaves, followed by this area turning white. This white area may measure half an inch to six inches long, and while most bend backwards, becoming disfigured by saprophytic fungi, some turn crisp, curl, and do not bend. Sometimes the apical attack is replaced by a marginal infection at any place from near the tip to about half-way down the leaf. As this area dies, the tissues contract and the leaf is twisted. Usually associated with these symptoms is a water-logged area developed half-way down or at the base of the leaf. The causal fungus can be found in the infected areas before chlorosis sets in, being abundant if there are moist conditions at the time (see Pl. XVIII).

Large plants when severely attacked rot away and break at the soil level when pulled. When all the leaves are affected, either their sale is impossible or the market value is reduced to prices which do not pay for their cartage. Young, badly diseased plants remain stunted, and pulling is not worth the labour. Slightly infected plants, while they may be bought once, will not be bought a second time by the public owing to the fact that the plants wilt overnight, whereas healthy plants will remain firm for many days.

The cause of the disease is a *Phytophthora*, and is readily found in the yellow, water-logged areas, less easily in the white areas. It is present as a large non-septate mycelium which is both inter- and intra-cellular. Oogonia with both paragynous and amphigynous antheridia are produced in abundance, while oospores are formed as the leaf dries up. The amphigynous antheridium is the dominant type in the

tissues. When the leaf is very wet or kept under very humid conditions conidia are produced also, but they have never been seen on the living host under field conditions. *Botrytis allii* Munn, *Pleospora Herbarum* (Pers.) Rab., *Fusarium* sp., yeasts and bacteria are the saprophytes which follow the *Phytophthora* infection and cause the rot which ensues. The mycelium can be traced from the leaves into the stem and even into the base of the plant, but it is very scarce in the base.

The isolation and artificial growth in culture of the parasite was long and troublesome. Cultures made direct from the host, even after external disinfection, were not successful. The methods employed either failed to kill the accompanying saprophytes or killed the parasite. Minute portions of the fungus, even though pure, died in culture tubes, possibly because they had not sufficient food in them to prevent death before the absorption of nutriment from the medium. Oospores and sporangia isolated from the host also failed to grow. Eventually the parasite was induced to grow as luxuriantly as possible in nutrient solutions. The yeasts and bacteria were washed away each day by placing the pieces of tissue in a funnel covered with muslin and running water passed through for several hours; the tissue was replaced in the nutrient and the process repeated several days. By this time the saprophytes, which hitherto had prevented the parasite from growing, were eliminated and the parasite had grown into a fair-sized mass of hyphae, which was cut off from the tissue and transferred to a Quaker Oat Agar culture, in which it grew and subcultures were subsequently taken.

Infection experiments to test the pathogenicity of the fungus isolated have been tried. Soil was sterilised and planted with young seedling Leeks; pieces of cultures were placed against some in the soil and between sets of pairs. In no case has infection resulted. In infection of leaves, the experiment at the time had to be run so that the uninoculated plants were within a short distance of the infected ones, and it is probable that the small percentage of uninoculated ones that became diseased was due to aerial distribution of the parasite. Slightly wounded and inoculated plants gave 77 per cent. infection, unwounded and inoculated 29 per cent., and uninoculated 18 per cent. In the experiments it was found that the fungus produced its conidia

profusely on the surface of the soil, and in many instances aerial infection of plants has been traced to this infected soil, and it is presumed that the conidia so produced are picked up by currents of air and carried to the aerial portions of Leeks. These conidia are smaller than those produced in water cultures, and this fact confirms their action as conidia—wind blown—rather than as sporangia. The fungus has been grown artificially in sterilised soil in petri dishes, and there it has formed surface conidia and deeper down abundant oospores. In the field, the action of many growers who plough in severely diseased crops places in the soil countless numbers of oospores. Even though the mycelium of the parasite is killed by unfavourable conditions—and this is almost certain—the oospores probably survive and germinate with the right conditions. The subsequent mycelium lives for a time saprophytically, then produces surface conidia which are blown on to the leaves of the host. It is probable that not every plant will be infected in such a manner, but a secondary epidemic may spread from these plants by conidia produced on the leaves. They cannot be numerous, as they have not yet been seen in the field by the writer. It is possible that sporadically, according to temperatures, they will be produced for a very short time in moderate numbers, and this will account for the occasional observations that spread may occur in the direction of wind. It is probable that conidia are produced externally on the leaves—they are produced internally when the leaves are moist—when the air is very humid, such as in mists. The theory of wind distribution was supported by the facts in 1928, when, during the critical period, and in a certain area, the direction of the prevailing wind was in the north-east, and the disease rapidly spread to the south-west. In 1930 spread was negligible, and odd-shaped diseased areas were dotted about indiscriminately, usually coinciding with the ploughing in of previously diseased Leeks. The weather was certainly different to that of 1928, and may be held responsible for the absence of spread from each of these small areas, in themselves infected by currents in the crop carrying conidia from the soil level up to the leaves.

There is the remarkable fact that this disease does not appear till late in the season. In the season 1928–1929 the

disease began in September, in 1929–1930 in January, and in 1930–1931 in December. In the Cheltenham district, in England, the disease may commence in August, but chiefly spreads in October to December, according to Ogilvie, who is keeping the disease under observation in that area. That the seasonal variation is connected in some way with temperature is quite likely; yet temperature cannot be entirely the cause. If the disease were connected with low temperatures, why should it start in August in the south of England and in September in Scotland, for if anything, the low temperatures would be later in appearing in England than in Scotland? Higher temperatures might explain the difference between the two localities, and to a less certain extent between the seasons. Infection might take place at the higher temperatures of July or early August in both localities, but the higher range in England might lessen the incubation period, and so the first signs appear in August, while the lower range in Scotland, although high enough for infection, might increase the incubation period as compared with England. This may be quite likely. It is significant that the mean temperature for the Bristol area, Bath being the station, including Cheltenham, is 61.5° F. in July, 60.7° F. in August, and 56.7° F. in September; while for the Edinburgh district, Leith being the station, the mean is 58.6° F., 58.3° F., and 54.7° F. for July, August, and September respectively. The optimum temperature for conidial production is 15–18° C. (59–64.4° F.), and the fact that the Bath mean temperatures for July and August fall within the conidial optimum, while those of Leith do not, suggests that there may be some correlation there.

It has been suggested that the onset of disease corresponds with the winter checking of host growth. But this is not so easy to support as the previous supposition, as the host growth is more likely to be checked first in the Lothians and later in the Cheltenham district, while the disease appears in Cheltenham before it does in the Lothians.

LIFE-HISTORY AND MORPHOLOGY OF THE PARASITE.

The *Phytophthora* responsible for the disease grows very well on Quaker Oat Agar, producing a dense, white mass of

aerial mycelium but not much submerged mycelium. Sexual organs are formed in the medium and on the aerial hyphae, where also conidia are formed. In plate cultures there is a margin of 5 mm. where no aerial mycelium is formed, while immediately adjoining the margin is a dense mass of white hyphae. There is also a marked striation from the centre. On Maize Meal Agar and Potato Agar growth is rather similar but less vigorous. On Potato Dextrose Agar cultures are similar to the above, but whereas oospores are plentiful before seventeen days, conidia are absent. On Malt Extract Agar growth is very poor and exceedingly slow, and aerial hyphae are almost absent. Colonies are solid and show radial striations. Sexual organs are produced very sparsely after four months. On Nucleic Acid Agar growth is slow and almost entirely submerged. Sexual organs are not produced. On Clear Maize Agar growth is rapid and regular, but aerial mycelium is sparse. Sexual organs are formed, and this medium was used for observing their development. As certain species resembled this fungus in one or two characters, they were grown at the same time at 25° C. on Clear Maize Agar. In seven days the Leek *Phytophthora* had a diameter of 27 mm., *Phytophthora Richardae* was 44 mm., and *Phytophthora pini* was 76.5 mm. The fungus was grown on plate cultures of 10 c.c., 12.5 c.c., 25 c.c., and 50 c.c. of Quaker Oat Agar. and in eleven days measured 80 mm., 77 mm., 53 mm., and 50 mm. respectively. This suggests that the fungus grows into the medium as this increases in depth, to approximately 2-3 mm., and then no increase in depth will influence its area; it is suggested that the fungus is aerobic and will not grow deep, as reasonable aeration soon becomes impossible.

It was found that this fungus grows saprophytically in the soil. Petri dishes containing sterilised soil were inoculated with pieces of cultures of the fungus, and when the mycelium had grown well over the soil, transfers were made from this to fresh plates and in these the fungus continued to grow. It can therefore obviously grow in soil apart from food contained in the piece of culture. In these soil cultures oospores and conidia were produced abundantly. This adds yet another *Phytophthora* to the many which De Bruyn (3) has succeeded in growing saprophytically in the soil.

GENERAL DESCRIPTION.

(a) *Mycelium*.—The mycelium of this fungus is typical of the genus but exhibits the characteristics to an extreme degree. It is very granular and branches only moderately. Septa are rare in young cultures but fairly frequent in old cultures, particularly those on rich media. The species has a characteristic which tends to differentiate it from other species; this is its great tendency to coil into one or more spirals, and this is more noticeable in the region of sexual activity. The mycelium is also rather unequal in width and often swells out into large, long vesicals which do not represent any form of spore. It is often swollen considerably where it branches. The submerged hyphae seem very rich in fats, for when they are broken immense quantities of fat globules escape. When fairly old the mycelium becomes empty, as in most species in the genus.

(b) *Sexual Organs* (figs. 1 and 2). These are produced quite abundantly in several media, such as Quaker Oat, Maize Meal, and Clear Maize Agars. They are also produced very readily in the diseased tissues of Leeks. Sterile pieces of mycelium, produced in the method used by Leonian (11), formed them in certain liquid cultures as well. In this species both types of antheridia are produced abundantly, but the proportion of the one to the other varies with the medium or substratum in which they are formed. On Quaker Oat Agar the paragynous type is very dominant, but the amphigynous type is still common. On Maize Meal Agar the proportion is practically 50:50, while on Clear Maize Agar the dominant type is amphigynous.

There was a chance that the amphigynous and the paragynous antheridia were produced by two different species obtained in culture, one or other or both being responsible for the disease. It would no doubt have been difficult to have separated these had this been correct. By very careful tracing of the two types of antheridia, the hyphae which produced them were seen to arise from a common mycelium. Cultures which had been taken from the edges of colonies in petri dishes, a quantity of branching mycelium produced from a single hypha being used, gave both types of antheridia. Therefore this should dispel not only any doubts as to whether

two species were present, but also any doubts as to the presence of heterothallism in the genus. Narasimhan (13) found that certain strains isolated from various plants in Mysore were non-sexual, but that when two were paired, sexual organs were formed, while when one of these and still another strain were paired, no sexual organs were formed. He argued from his results that one strain was female and the other two male, and only when one or other of the male

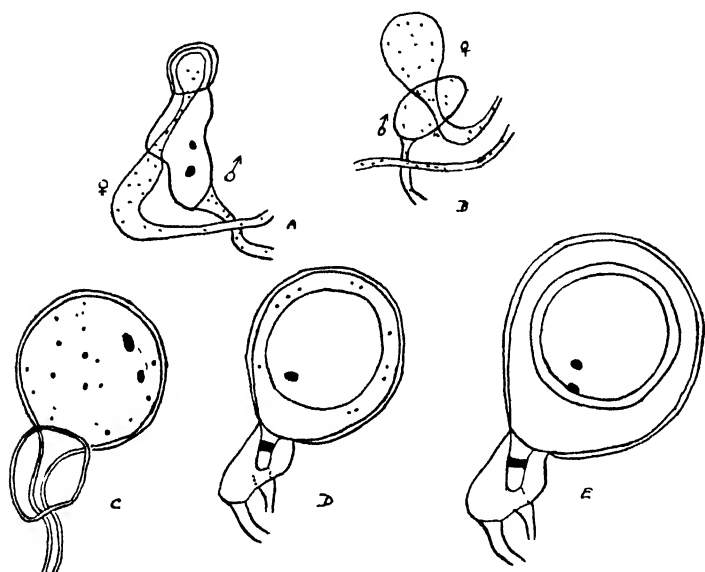


FIG. 1.—*Phytophthora Porri*. Diagrammatic sketches of amphigynous fertilisation. A and B. Passing of the oogonial concept through the antheridium. C. Disintegration of nuclei and collection of cytoplasm for oosphere. D. Oosphere formed. E. Oospore formed, with female and male (peripheral) nuclei shown.

strains were paired with the female strain could sexual organs be produced. But although heterothallism occurs in some species it does not follow that every species will be heterothallic. In the case of the Leek *Phytophthora* and other homothallic species, there may be generic characters which determine the production of the two types of antheridium, and their proportion may be further influenced by various external factors.

The amphigynous antheridium is produced in the same

manner as already described for *Phytophthora erythroseptica* by Pethybridge (15).

The paragynous antheridium attaches itself to almost any part of the oogonium, sometimes being so close to the stalk of the oogonium that it appears to be amphigynous. More than one may be attached to the one oogonium sometimes, and once an oogonium had both an amphigynous and a paragynous antheridium.

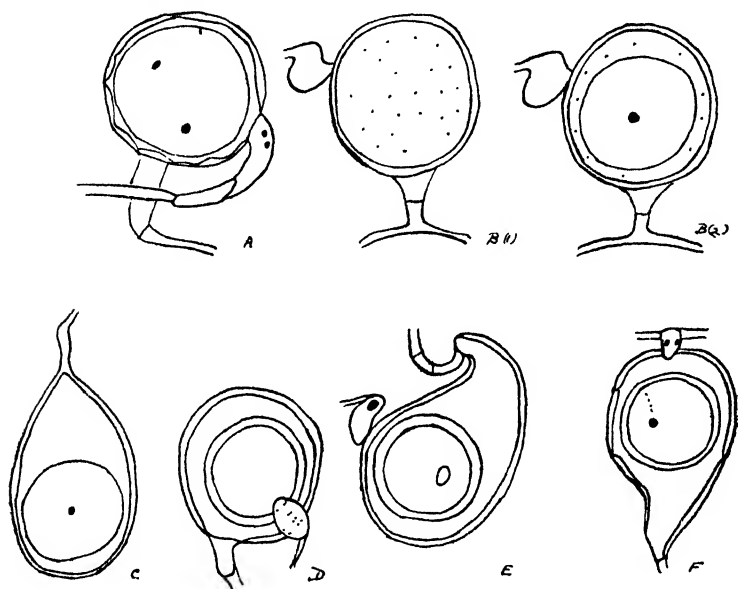


FIG. 2.—*Phytophthora Porri*. Diagrammatic sketches of paragynous fertilisation. A. Oosphere formed. B (1). Stage prior to B (2), the oosphere stage. C. Oosphere. D-F. Oospore stages. F. Showing irregular wall of oogonium in particular.

The oogonial wall is rather thicker than in some species and is hyaline. After the oospore is mature the oogonium tends to collapse and presents a very irregular shape. The oospore is spherical, usually light yellow in colour, with a wall which is thicker than usual. It usually does not fill the oogonium. Not only is the oogonial wall liable to collapse, but it is often irregularly thickened. This is also found in the oogonia of *Phytophthora Lepironiae*.

(c) *Asexual Organs* (fig. 3).—Conidia are the only asexual form so far found in this species. They are produced in the

diseased leaves as well as in artificial culture, but in the latter they are not very abundant. They are produced more readily if pieces of pure cultures are placed in water and certain liquid cultures. They are inversely pyriform, with or without an apical papilla. When this is present it is broad more often, though a beaked kind is also sometimes formed. The hyaline thickening at the apex is not very prominent and might be said generally to be shallow. The non-papillate form is far the more common. They may germinate either by germ tube or by zoospores. The formation of the zoospores and their emission is similar to that already described for many other species of *Phytophthora*. The zoospores germinate by a germ tube which develops

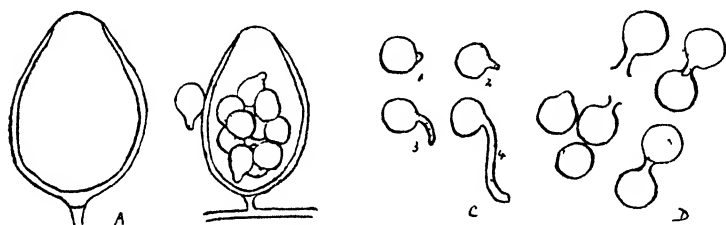


FIG. 3.—*Phytophthora Porri*. Diagrammatic sketches of conidial stages. A. Terminal conidium. B. Intercalary conidium with half the zoospores unexpelled. C. Germinating zoospores. D. Diplanetic zoospores, two of which have not broken away from the mother zoospore.

into a mycelium. But in this species repetitional diplanetism has been found, though only once, nor could the phenomenon be repeated. When the zoospores are emitted they swim only a short distance, then settle down, form a wall, and germinate by a short tube from the end of which another zoospore is emitted. In other words, the primary zoospore acts as a sporangium. All the contents of the first zoospore pass into the new zoospore, and this breaks away, swims normally, and ends up by germinating in the usual way to produce a mycelium. Drechsler (7) found another type of diplanetism in which the zoospore after encystment produces a long, slender germ sporangiophore, at the tip of which a small sporangium is formed. This may also be formed from an unsuccessful evacuation tube. The miniature sporangium forms one zoospore from its contents, and this is liberated. The latter method has not been found in this fungus so far.

It often happens that the zoospores are not liberated from the sporangium, and these encyst and germinate by a tube, which may grow through the sporangium wall. The number of zoospores produced in the sporangium depends upon the size of the latter. Over twenty have been counted from one sporangium, while in others a few were left inside the sporangium and others were bunched outside; the numbers could not be determined with certainty, but they were between fifteen and twenty. A small kind of sporangium has been found in this fungus, which is more spherical than the normal type and forms only a few zoospores, perhaps three to five. These were not the miniature sporangia produced from zoospores referred to before. They have not been found again. They were produced in a hanging-drop culture on Clear Maize Agar, the same in which the diplanetic zoospores were produced. Neither have been seen in liquid cultures as described by Dreschler. According to him, the direct type of repetitional development of the zoospore was observed in *Phytophthora Fagi*, the indirect type in *Phytophthora hibernalis*, and both types in *Phytophthora parasitica* and some strains referable to it, *Phytophthora Cactorum*, *Phytophthora citrophthora*, *Phytophthora melongenae*, and a strain from Honey-dew Melon.

The direct germination of the sporangium by a tube may take place either at the apex or just below it. The sporangia are produced at the ends of hyphae and also intercalarily. The sporangiophore may be inserted in the usual place, at the centre of the broader end, or on one side. No plano-convex sporangia have been noticed, as was found by Leonian in *Phytophthora pinu*. A few sporangia, both in water culture and in tissue, have a pedicel.

MEASUREMENT OF THE FUNGUS.

(a) *The Mycelium.* This varies rather considerably according to whether it is aerial, when it is thin, or in the substratum, when it is thick. Rich media tend to produce very variable hyphae which swell out into odd shapes. There is no stability in the mycelium in the tissue either. The average width approximates 6-8 μ , and the range is about 2.4-12 μ .

(b) *The Sexual Organs.*—Precautions were taken to measure only mature organs.

TABLE I.

Measurements in μ of the Sexual Organs.

Substratum.	Oogonia.		Oospores.	
	Mean.	Range.	Mean.	Range.
Quaker Oat Agar . . .	38.367	46-29	32.369	39-23
Water	37.864	44-33	31.679	39-22
Bog Water	38.966	44-32	33.144	39-27
MgNO ₃ (1 : 1000) . . .	39.123	46-34	32.272	39-27
Tissue	34.596	44-29	29.022	36-19

The writer's figures which were given in the first record of the disease (8) were not representative and should be replaced by the present figures.

It is to be noticed that the oogonia and the oospores in the host are much smaller than those in solid and liquid culture.

The mean of the organs may therefore be stated to vary between 38 and 39 μ for the oogonia, and between 32 and 33 μ for the oospores.

The antheridia average 12.5 μ but range from 7.3 to 19.4 μ . One abnormal one was found in magnesium nitrate solution and measured 24.2 μ . The amphigynous antheridia are usually larger than the paragynous, being approximately twice the size.

The oospore wall, which has three layers as described for *P. erythrosetptica*, varies between 3 and 4.5 μ thick, the average being about 4 μ . The outer layer is about 0.4 μ and the inner 0.2 μ , the rest, 3.4 μ , being the middle layer. It is rather a thick wall when compared with some other species.

(c) *The Asexual Organs.* The conidia also vary in size according to the conditions of production. On the leaf they tend to be larger than when they are produced in solid culture or in liquid culture. Only normal, mature spores were measured.

TABLE II.
Measurements in μ of *Conidia*.

Substratum.	No.	Mean.	Range.	Mode.
Host . .	100	58×42	$75-37 \times 48-31$	1.38
Water . .	200	51×35	$82-31 \times 52-23$	1.46
Soil . .	10	46×32	$55-31 \times 42-28$	1.44
Water ¹ . .	?	47.9×32.9	$62-33 \times 45-25$	1.46

¹ These measurements were kindly made by Dr. Ashby, to whom the author sent a culture.

The question arises as to what measurements are to be taken for comparative purposes. These conidia are not like those of *Phytophthora infestans*, which are produced naturally and abundantly aerially on the leaf, or on diseased tubers when cut and kept in a humid atmosphere. They are produced in culture, but not enough to use them for metrical purposes, particularly when they are produced abundantly in liquid culture. For this purpose a survey of the species thought to be nearest to this one must be made. This will be deferred for the moment and discussed under the subject of taxonomy.

The wall of the conidium is approximately 2.4μ thick, except at the apex. There is a plug at the point of production of the conidium on the conidiophore. The proportion of the length to the width of the conidia is rather constant, and is 1.46.

The papillae when they are present are about 5μ high and the width of the apex is about $10-12 \mu$. The beaked forms of papillae are usually 12μ long.

The zoospores vary in size. The usual size is about $10-15 \mu$, that is when they have stopped swimming and rounded off. But the kind which produced secondary zoospores were larger, averaging, when they had rounded and produced the emission tube, 18.7μ , and ranging $17.4-20.4 \mu$. The tube that is formed is about 5μ long, but longer ones, up to 10μ , are also produced.

THE RELATION OF TEMPERATURE.

Petri dishes of Maize Meal Agar were inoculated with a 3-mm. square of a culture of *Phytophthora Porri* and grown at three different temperatures—in an incubator at 25° C., in the laboratory at 18°–20° C., and in a glass-house at 8°–10° C. The rates of growth are very different.

It was found that the fungus grew best, vegetatively, at 25° C. and that the minimum must be below 8° C. Cultures kept in an incubator running between 30° and 33° C. hardly grew at all, while cultures at 40° C. were killed. It may be concluded that, within the ordinary limits of variation, the minimum, optimum, and maximum temperatures for the vegetative growth of the Leek *Phytophthora* are below 8° C., 25° C., and 35° C., while the death-point is at or slightly below 40° C.

Temperature also influences the production of conidia in liquid cultures, though not entirely. Conidia are produced at 23°–25° C., but are very few and are very small and slender. They are really abnormal. At room temperature, 18°–20° C., they are produced fairly well, but abundantly at 15°–18° C. At 10° C. no conidia are produced. These relations seem to place the Leek *Phytophthora* in the temperate group. Temperate species chiefly produce conidia at temperatures between 16° and 25° C., while tropical species require temperatures above 20° C., maximum production occurring at 27°–30° C. For example, Jones, Giddings, and Lutman (9) found the maximum number of conidia of *Phytophthora infestans* at 16°–18° C., but not below 10° or above 23° C. With the same fungus other workers obtained higher temperatures for the best conidial production; Vowinkel (26) obtained 19°–22° C. and Melhus (12) 22°–25° C. Rose (17) found the optimum temperature for *Phytophthora Cactorum* was between 10° and 20° C. Uppal (25) found 22°–23° C. was optimum for *Phytophthora Colocasiæ*. Waterhouse (27) found that her cultures of *Phytophthora Fagi* produced conidia in three days at 15°–20° C. but none at 22° C. Ashby (1) found that the more tropical species *Phytophthora parasitica* had an optimum conidial temperature of 27°–30° C., and Reinking (16) with *Phytophthora Faberi* (= *Phytophthora palmivora*) found an optimum of 27°–30° C. also, but no conidia were produced

below 20° C. Although conidia of *Phytophthora Fagi* were produced best at 15°–20° C. according to Waterhouse, the best vegetative growth of the same fungus was at 22° C. This is similar to *Phytophthora Porri*, although the temperatures are not exactly the same.

THE RELATION TO LEONIAN'S PHYSIOLOGICAL KEY.

The method used by Leonian (11) for determining the effect of chemicals on the production of conidia and oospores in culture was used by the writer. The procedure was as follows. A small portion of a Quaker Oat culture of the fungus was placed in a petri dish containing a nutrient solution made up according to Leonian's formula. As no growth was made in this culture it was taken out and washed in running water for an hour and then transferred to a petri dish with fresh nutrient solution. After three days good vegetative growth had been made, but as there were a few bacteria the colony was again washed in running water and replaced in fresh solution. The growth was now very good, and two small pieces were teased off the large colony with sterile forceps and one each placed in a dish. A set of petri dishes was now poured with solutions containing one-hundredth the molecular weight of various chemicals and each inoculated with a piece of colony from each dish. The results are given in Table III.

TABLE III.

Effect of Chemicals on Spore Production in P. Porri.

Aspartic acid	None.
Potassium nitrate	Sporangia.
„ carbonate	None.
„ acid phosphate	None.
Calcium nitrate	Sporangia.
Sodium chloride	Sporangia.
Ammonium nitrate	None.
„ sulphate	None.
Magnesium sulphate	Sporangia.
Dextrose	None.
Glycine	Sporangia ; oogonia.
Levulose	Sporangia.
Mannose	None.
Leucine	None.
Nutrient solution	None.

Oogonia are produced on Malt Extract Agar, and no oogonia and no sporangia are found in Nucleic Acid Agar.

By the colonies produced on Malt Extract Agar and the absence of sporangia in Aspartic Acid group six of Leonian's key is reached, and the formation of oogonia in Malt Extract Agar places the fungus in group seven. The absence of sporangia in Leucine or Ammonium Sulphate would identify the fungus as *Phytophthora pini*. If it were conceded that the number of oogonia on Malt Extract Agar were too few and could be taken as equalling Class I of Leonian's analysis, this would take the fungus into group eight of the key. No sporangia are produced in nutrient solution and no chlamydospores are produced in any medium. The finding of sporangia in potassium nitrate and in sodium chloride solution, but not in mannose solution, places the fungus in group fifteen. As sporangia are produced liberally, at room temperature, in water although not in leucine, this would identify the fungus as *Phytophthora Nicotianae*. No other than the two species mentioned can be considered from the results of the physiological experiments and using Leonian's key. There are reasons otherwise for rejecting both of these two species.

TAXONOMY OF THE FUNGUS.

No *Phytophthora* has been recorded on the Leek (*Allium Porrum*) before; nor has any other species of *Allium* been recorded as naturally infected by a *Phytophthora* except *Allium fistulosum*, the Japanese Welsh Onion, which was found to be attacked in Formosa in 1913 by a new species erected as *P. Allii* by Sawada (18). The fungus *P. Allii* did not infect *Allium Ceba*. The present strain was therefore compared with *P. Allii* and was found to be quite different.

Never has a single onion (*Allium Ceba*) been found affected with White Tip disease, although leeks and onions have been grown in proximity for years. But it is agreed that the host of a *Phytophthora* is not an indication of its identity. Several species attack many hosts, e.g. *P. parasitica* and *P. cryptogea*. That one species has been recorded on a certain host is no reason why a newly discovered species on a different host should not be identical with the first. The Leek *Phytophthora* has no right to a binomial such as *P. Porri* just because no *Phytophthora* had been found on that host. Nor can the Leek *Phytophthora* be distinguished from *P. Allii* because the latter

is on a different host. Identification has, in the past, been associated with morphological features, such as shape, type, presence and size of sexual organs, or asexual reproductive bodies. Since it has been demonstrated that the morphological characters and life-history can be varied by the influence of external factors, they cannot be entirely reliable for diagnostic purposes. Leonian (11) made a key for the identification of the species in the genus *Phytophthora* based on physiological characteristics, but it is claimed for the fungus described here that the key is not sufficient to identify it, as shown above in the experiments conducted similarly to Leonian's method. The trouble with the keys so far formulated is that they only take into consideration the species already discovered. It is the new strains of *Phytophthora* which upset the keys, for surely if they did not do so then they would not be new. In the case of the Leek parasite, each key identifies it as a different species. By Leonian's key (11) it is either *P. pini* or *P. Nicotianae*; by Tucker's key (24) it is *P. Cactorum*. These three species can be compared with the Leek fungus along with others which have one or more characters which approximate one or more characters of the Leek fungus.

It was seen that the Leek fungus has the following measurements in μ :—

Oogonia : mean, 38-39 ; range, 46-29. Culture.

Oospores : { „ 32-33 ; „ 39-22 ; wall, 3-4.5. Culture.
 { „ 29 ; „ 36-19. Host.

Conidia : { „ 58 \times 42 ; „ 75-37 \times 48-31. Host.
 { „ 51 \times 35 ; „ 82-31 \times 52-23. Water.
 mode, 1.38-1.46.

Antheridia : mean 12.5 ; range 19.4-7.3.

Phytophthora Allii Sawada (18). On *Allium fistulosum*.
 Formosa.

Oogonia : mean, 20.7 ; range, 26-17. Host only.

Oospores : „ 16.9 ; „ 23-14 ; wall, 0.5-1.5.

Host only.

Conidia : „ 49.4 \times 36.5 ; range, 74-40 \times 50-30. „
 mode, 1.38.

Antheridia : 18-8 \times 14-10, amphigynous only.

Taking into consideration the fact that the measurements are of the fungus on the host only, there is still a great deal of difference between the sexual organs of this fungus and the Leek parasite. The conidia have almost the same range as those on the Leek leaves, although the mean is much lower. The shape of the conidia and the mode are the same in both, and both have hemispherical papillae almost the same size. The Leek fungus has, in addition, the beaked form of papillae. But conidia are the most variable part of the fungus, and many species overlap. This has been included by Ashby in the "microspora" group of *Phytophthora parasitica* emend. This does not approach closely to the Leek fungus.

Phytophthora cyperi-rotundati Sawada (21). On *Cyperus rotundatus*. Formosa.

Oogonia : mean, ... ; range, 47-31 \times 45 25. Host only.

Oospores : ,, 30.8 ; ,, 29 22 ; wall, 1-3. ,,

Conidia : ,, 45.4 \times 25.1 ; range, 67-22 \times 34-14. ,,
mode, 1.81.

Antheridia : Para. 20-13 \times 13 11 ; Amphi. 16 13 \times 22-19.

It is seen that the range of oogonia approximates to the Leek fungus, while the oospores have exactly the same range in both. In the translated description (from the Japanese) sent by Ashby to the writer, is "Oospores . . . 22-39, mostly 32 ; average (150) 30.8." It is peculiar that the 'mostly 32' is the same as the mean for the Leek oospores. The conidia are smaller and narrower than the Leek conidia. A short, thickened pedicel is present. These are all on the host though, and the oospores on the host in the case of the Leek fungus are 3 μ smaller and have a lower range. This fungus approaches the Leek fungus, but has not been adequately described from the host alone. The disease is prevalent at 25°-28° C., much higher than the Leek disease.

Phytophthora Lepironiae Sawada (19, 20). On *Lepironia mucronata*. Formosa and South China.

Oogonia : mean, ... ; range, 52 40 \times 48-40 ; wall, 4 (!).

Host only.

Oospores : ,, ... ; ,, 38-30 ; wall, 3-4. ,,

Conidia : ,, 54 \times 44.6 ; range, 64-40 \times 52-36.
mode, 1.21.

Antheridia : Paragynous, 24-20 \times 16-14.

Here the oospores and oogonia on the host are larger than those on the Leek fungus on the host. The conidia are smaller and broader than the Leek conidia, though similar in being mainly non-papillate. The oogonial wall is unequally thickened, but thicker than in the Leek fungus. Only paragynous antheridia were found in the host tissues. This is less like the Leek *Phytophthora* than *P. cyperi-rotundati*.

Phytophthora Pini Leonian. On *Pinus resinosa* (11).

Oogonia : mean, 29 ; range, 37–18·5.
 Oospores : „ 26 ; „ 34·2–16·7 (Tucker).
 Conidia : „ 55·5 × 35 ; „ 92·5–26 × 44·5–22.
 mode, 1·59.

Antheridia : Paragynous mostly, also amphigynous.

The size of the conidia is not the same as the Leek fungus, but is near enough if only the oospores were the same size. These latter are much too small, being 26 μ in mean. The antheridia are mostly like the Leek *Phytophthora*, especially in the habit of multi-fertilisation ; the cultural characters are not similar. The narrower conidia, with definite or blunt papillae, of this fungus are not quite similar to the Leek conidia. Tucker makes this synonymous with *P. Cactorum*.

Phytophthora Cactorum (L. & C.) Schroet. On many hosts.

Oogonia : mean, 29·4 26·8 ; range, 38·4–18·4.
 Oospores : „ 26·5–24·2 ; „ 34·2–16·7.
 Conidia : „ 30 39–22·77 ; „ 31–17 × 40 23.

The above figures are given by Tucker (24), who states that the antheridia are almost entirely paragynous. The conidia are small and inconspicuously papillate. It grows best at 25°–27·5° C. The measurements do not approximate to those of the Leek fungus, which also has different cultural characteristics.

Phytophthora hibernalis Carne. On Citrus (6).

Oospores : 45·6–22 ; mean, 35.
 Conidia : 56–17 × 28–10.

Antheridia : Mainly amphigynous, rarely paragynous.

The conidia are too small, although the average oospore size may be near to that of the Leek fungus. Fuller figures are not given. The cultural characters are different from the

Leek fungus. It seems, in addition, a far cry from a citrus to a leek.

Phytophthora Richardiae Buisman. On *Richardia* (4, 5).

Oospores : mean, 29.

Conidia : „ 52 × 33.

The antheridia are entirely amphigynous, and its affinity is with *Phytophthora cryptogea*. Indeed Ashby considers *P. Richardiae* merely a variety of *P. cryptogea*. Its growth on media is not similar to the Leek fungus.

Phytophthora Capsici Leonian (10). On *Capsicum annuum*.

Oospores : range, 25-35.

Conidia : „ 83-35 × 56-21.

Antheridia : Amphigynous.

The measurements are not helpful, as they are only ranges, but taking into consideration the antheridium, the host, the physiology (Leonian's key), and its cultural peculiarities, none of which are similar to those in the Leek fungus, it is almost certainly not the same.

Phytophthora citrophthora (Smith & Smith) Leonian. On Citrus (22, 23, 11).

Oospores : range, 40-30.

Conidia : mean, 50 × 35 ; range, 90 30 × 60 20.

The conidia are very close to those of the Leek fungus, but as it does not form oospores on Oatmeal Agar and forms sporangia and aerial hyphae on Nucleinic-acid Agar, while the Leek fungus does just the opposite, this species need not be considered. The cultural characters are also different.

Phytophthora Nicotianae Breda de Haan (2).

Oogonia : mean, 30 (Ashby), 27.8 (Tucker).

Oospores : „ 24.3 „ 23.5 „

Conidia : „ 41.2-35.1 × 25.2-21.7 (Tucker).

Antheridia : amphigynous.

Tucker has renamed this species *P. parasitica* var. *Nicotianae*. The measurements are generally too small to permit the identification of this species with the Leek parasite. Tucker identified *P. tabaci* Saw. with this species. This species also thrives best at high temperatures, the optimum

being 25°–30° C., which is higher than that for the Leek fungus.

It seems, therefore, that the species that approach in any measurement to the Leek fungus vary even in these respects and more often in others, such as antheridial type, cultural and physiological characters. The nearest are *Phytophthora cyperi-rotundati* and *Phytophthora Pini*, but in *P. Pini* the cultural characters, the oospores, and partly the conidia are too divergent to connect the Leek *Phytophthora* with it; while in the case of *Phytophthora cyperi-rotundati* the size and shape of the conidia, the pedicel, the slightly larger (host) oospore, and the high temperature of the disease deny a reasonable connection with the Leek fungus also.

The species can be diagnosed as follows :—

***Phytophthora Porri*, n. sp.**

Mycelium ramosum, in juventate non-septatum, tandem multi-septatum atque vacuum, in regione sexuali in spiras contortum. Conidia inversi-pyriformia vel ovalia, $51 \times 35 \mu$ ($82-31 \times 52-23 \mu$), ad apices conidiophorum producta vel intercalaria, plerumque papilla deficiente, nunc papilla lata $5 \times 10-12 \mu$ nunc papilla rostrata $12 \times 10-12 \mu$ praedita; callositas apicalis hyalina $2.5-5.0 \mu$ crassa; ostiolum latum; conidium ipsum in germinatione evolvit vel tubum vel zoosporidia $10-15 \mu$ quae iterato zoosporidia producunt vel nunc tubum. Antheridia ovalia vel complanato-sphaerica, terminalia vel intercalaria, in eadem hypha unà cum oogonio haud inventa, aut amphigyna 12.5μ ($19.4-7.3 \mu$), aut paragyna $10-7.3 \mu$. Oogonium maturum sphaericum, muro inaequaliter incrassato munitum, $38-39 \mu$ ($46-29 \mu$), fecundum antheridio paragyno unico plerumque adjuvante, nunc pluribus, nunc antheridio amphigyno, nonnunquam ambobus eodem tempore. Oospora sphaerica, maturitate melleo-flava, $32-33 \mu$ ($39-22 \mu$), muro crasso $3-4.5 \mu$ cincta. Conidia in aqua atque in hospite abunde producta, in cultura solida infrequentia; genitalia in cultura solida vel liquida atque in hospite creberrima. In foliis caulibusque *Allii Porri* Linn. parasitica, ubi areolas aquosas, tandem albescentes praesertim ad apices foliorum inducit. Hab. in ins. Britannicis.

Mycelium branched, non-septate when young, septate and

empty when old, coiled in spirals in region of sexual activity. Conidia inversely pyriform or oval, $51 \times 35 \mu$ ($82-31 \times 52-23 \mu$), produced at the end of conidiophores or intercalary, usually without a papilla, occasionally with a broad papilla $5 \times 10-12 \mu$, sometimes with a beaked papilla $12 \times 10-12 \mu$; apical thickening $2.5-5.0 \mu$ and hyaline, mouth of discharge broad, germination by a tube or by zoospores $10-15 \mu$, which may germinate in turn by zoospores (repetitional diplanetism) or by a germ tube. Antheridia oval or flattened spheres, terminal or intercalary, not on the same hypha as oogonium; when amphigynous 12.5μ ($19.4-7.3 \mu$), and when paragynous $10-7.3 \mu$. Mature oogonium spherical, with an unevenly thickened wall, $38-39 \mu$ ($46-29 \mu$), fertilised mostly by one paragynous antheridium, sometimes by several paragynous antheridia, sometimes by an amphigynous antheridium, and sometimes by both types at once. Oospore spherical, honey-yellow when old, $32-33 \mu$ ($39-22 \mu$), with a thick wall $3-4.5 \mu$. Conidia produced abundantly in water and in the host, less often in solid media; sexual organs formed abundantly in solid and liquid media and in the host. Parasitic on the leaves and stems of *Allium Porrum* Linn., causing water-logged areas, followed by a whitening of the tips of leaves and other affected parts. Hab. in Great Britain.

CONTROL.

It is too early to say much on the control of this disease as work is still proceeding on this line. But in 1928, when trials were started to control Downy Mildew of Leeks—which turned out to be this disease—three sprays were used. They were Bordeaux and Burgundy mixtures and Ammonium Polysulphide wash. To each was added soft soap to aid adhesion, as liquids roll off the waxy leaves of Leeks very readily. Although the Leeks were already infected when sprayed, it was found that the Ammonium Polysulphide had the best effect in reducing the intensity of the disease. In England, Ogilvie and Mulligan (14) used a Copper-Lime dust, and have reported fair success in controlling the disease. In Scotland conditions are not so suitable for the use of a dust, but further trials are to be made of various possible controls.

The author wishes to record his indebtedness to Professor W. Wright Smith for laboratory facilities and for preparing the Latin diagnosis, to Dr. Malcolm Wilson for his criticism and general supervision, to Dr. S. F. Ashby for translations of the Japanese papers and for his help in the taxonomy, and to Mrs. N. L. Alcock for her constant encouragement and for facilities given for the purpose of this research.

SUMMARY.

A disease of Leeks called "White Tip" is described which in the last few years has become of considerable economic importance. The symptoms include the yellowing and dying of tips of leaves, which turn white, and water-logged areas which develop lower down. The parasite is a *Phytophthora*; its presence in the host and its isolation and growth in artificial culture are described. Infection experiments did not support a hypothesis of root or basal attack, but supported leaf attack. The parasite grows in the soil saprophytically, produces conidia on the soil surface, and these are supposed to be blown on to leaves, whence infection takes place. The seasonal appearance of the disease is discussed and some meteorological factors are given in explanation of its later appearance in Scotland than in England. The life-history, morphology, and physiology of the parasite is described in detail, and comparison is made with several species. It is decided that it is a new species and is named *Phytophthora Porri*, with a diagnosis in Latin and English. Control measures are discussed, but have not been properly worked out yet.

REFERENCES.

- (1) ASHBY, S. F.: The Oospores of *Phytophthora Nicotianae* Br. de Haan, with notes on the taxonomy of *P. parasitica* Dastur. Trans. Brit. Myc. Soc., xiii (1928), 86-95.
- (2) BREDA DE HAAN, J. VAN: De bibitziekte in de Delitabak veroorzaakt door *Phytophthora Nicotianae*. Meded. Lands. Plantentuin, xv (1896), 107 pp.
- (3) BRUYN, H. L. (J. DE): The Saprophytic Life of *Phytophthora* in the Soil. Meded. van de Landbouwh., xxiv, 4 (1922), 1-38.
- (4) BUISMANN, C. J.: *Phytophthora Richardiae*. Meded. u. h. Phytopath. Labor. "Will. Comm. Schol" Baarn, xi (1927).
- (5) —: Een wortelziekte van Calla, veroorzaakt door een *Phytophthora*-soort. Tijdschr. over Plantenz., xxxiii, 2 (1927), 17-22.

- (6) CARNE, W. M. : A Brown Rot of Citrus in Australia (*Phytophthora hibernalis* n. sp.). Journ. Roy. Soc. West Australia, xii (1925), 13-41.
- (7) DRECHSLER, C. : Repetitional Diplanetism in the Genus *Phytophthora*. Journ. Agric. Res., xi (1930), 557-573.
- (8) FOISTER, C. E. : White Tip Disease of Leeks. Gardeners' Chronicle, 3rd ser., lxxxv (1929), 106.
- (9) JONES, I. R., GIDDINGS, N. J., and LUTMAN, B. F. : Investigations of the Potato Fungus *Phytophthora infestans*. U.S. Dept. Agric., Bur. Plant Industr., Bull. 245 (1912).
- (10) LEONIAN, L. H. : Stem and Fruit Blight of Peppers caused by *Phytophthora capsici*, sp. nov. Phytopathology, xii (1922), 401-408.
- (11) — : Physiological Studies on the Genus *Phytophthora*. Amer. Journ. Bot., xii (1925), 444-498.
- (12) MELHUS, I. E. : Germination and Infection with the Fungus of the Late Blight of Potato (*Phytophthora infestans*). Wis. Agric. Exp. Sta., Res. Bull. 37 (1915).
- (13) NARASIMHAN, M. J. : Studies in the Genus *Phytophthora* in Mysore. I. Heterothallic Strains of *Phytophthora*. Phytopathology, xx (1930), 201-214.
- (14) OGILVIE, L., and MULLIGAN, B. O. : White Tip Disease of Leeks. Gardeners' Chronicle, 3rd ser., lxxxix (1931), p. 360.
- (15) PETHYBRIDGE, G. H. : On the Rotting of Potato Tubers caused by a New Species of *Phytophthora* having a Method of Sexual Reproduction hitherto undescribed. Sci. Proc. Roy. Dublin Soc., xiii (N.S.) (1913), 529-565.
- (16) REINKING, O. A. : Comparative Study of *Phytophthora Faberi* on Coconut and Cacao in the Philippine Islands. Journ. Agric. Res., xxv (1923), 267-284.
- (17) ROSE, D. H. : Leather Rot of Strawberries. Journ. Agric. Res., xxviii (1924), 357-376.
- (18) SAWADA, K. : *Phytophthora allii* K. Sawada, sp. nov., in Moji Shikenjo Tokubetsu Hokoku (Special Report Agric. Exper. Sta.), Taiwan (Formosa). No. 11, 59-60 (March 1915). (Abstracted by T. Tanaka in Mycologia, ix, 249.)
- (19) — : A Preliminary Report of a New *Phytophthora* Disease of *Lepironia mucronata* Rich. Agric. Exp. Sta. Govt. Formosa, Bull. 131 (1919).
- (20) — : *Nozemia lepironiae* Saw., in Descriptive Cat. of the Formosan Fungi, pt. 1. Agric. Exp. Sta. Govt. Formosa, Spec. Bull. 19 (1919).
- (21) — : *Phytophthora cyperi-rotundati* Saw., in Descriptive Cat. of the Formosan Fungi. Dept. Agric. Govt. Research Inst., Formosa, Rept. 27 (1927), 26-29.
- (22) SMITH, R. E., and SMITH, E. H. : A New Fungus of Economic Importance. Bot. Gaz., xlii (1906), 215-221.
- (23) — : Further Studies of Pythiaceus Infection of Deciduous Fruit Trees in California. Phytopathology, xv (1925), 389-404.
- (24) TUCKER, C. M. : Taxonomy of the Genus *Phytophthora* de Bary. Missouri Agric. Expt. Sta., Res. Bull. 153 (1931).
- (25) UPPAL, B. N. : Relation of Oxygen to Spore Germination in Some Species of the Peronosporales. Phytopathology, xvi (1926), 285-292.

- (26) VOWINCKEL, O. : Die Anfälligkeit deutscher Kartoffelsorten gegenüber *Phytophthora infestans* (Mont.) de Bary, unter besonderer Berücksichtigung der Untersuchungsmethoden. Arb. Biol. Reichs. für Land. u. Forstwirtschaft., xiv (1926).
- (27) WATERHOUSE, G. M. : The Production of Conidia in the Genus *Phytophthora*. Trans. Brit. Myc. Soc., xv (1931), 311-321.

STUDIES IN VEGETATIVE PROPAGATION: ACALYPHA, DIOSCOREA, AND STENOGLOTTIS LONGIFOLIA. By R. J. D. GRAHAM and L. B. STEWART. (With Pl. XIX.)

(Read 23rd April 1931.)

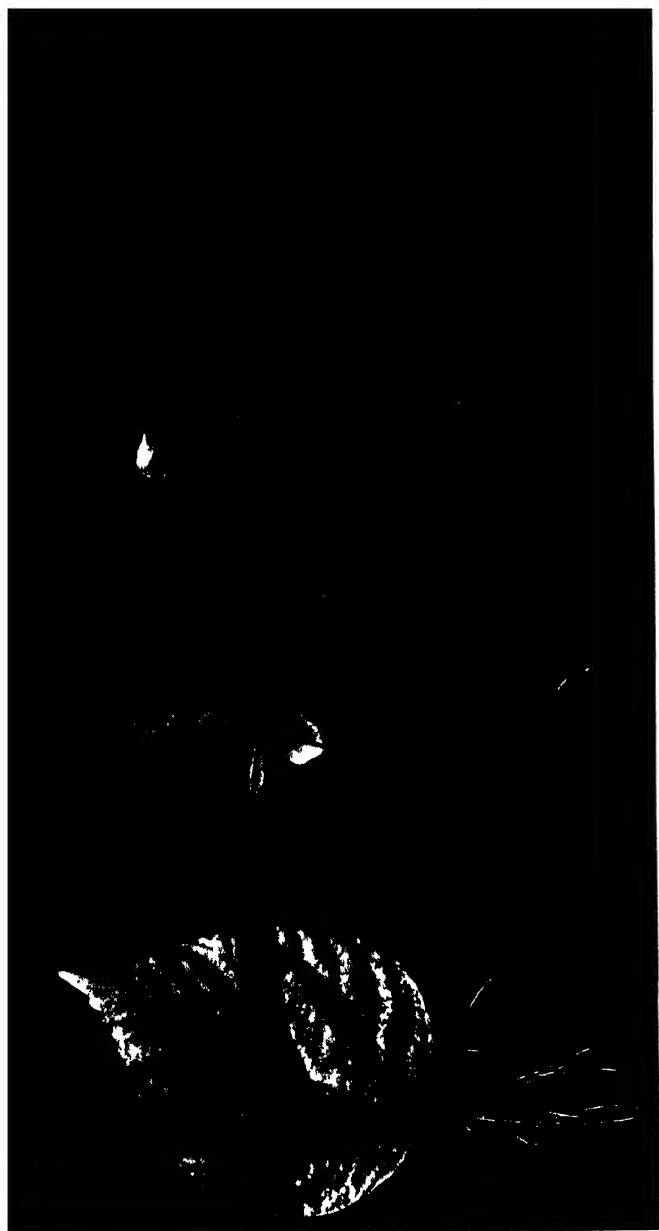
Attention was drawn in a paper (Acad. Wetenschapp. Amst. Proc., Sect. Sc., xxxii (1929), 35) by F. W. Went to *Acalypha Wilkesiana*. The author reported a specific root-producing substance in the leaf, but stated that the leaf itself did not produce roots.

The latter part of this statement is contrary to our experience in certain other species of *Acalypha*, whose leaves rooted freely. The species used in our propagation had green leaves whereas *A. Wilkesiana* has red leaves. Since the conditions inducing the development of anthocyanin are known to inhibit root development in regeneration among certain plants the matter was put to the test.

In October 1930 leaves of *A. Wilkesiana* were placed in the propagating frame. Within ten days the majority had rooted, the remainder rooting within the month. Root-production is not only possible but expeditious, and is so abundant that within three months the root system completely filled a 3-inch pot. Leaves with petioles rooted from the base of the petiole, the root development being more copious on the abaxial side (fig. 1). Leaves detached from their petioles root freely from the injured base of the lamina. Laminas in which the veins were incised also rooted freely from the lower end of the severed veins.

Anatomical investigation revealed the fact that root development is initiated in the cells of the vascular bundles external to the xylem. In one microtome section seven of the nine bundles in the petiole showed root initials.

Records of leaf propagation in Monocotyledons with ordinary—not fleshy—leaves are uncommon. In order to increase the number of records the leaves of various Monocotyledons, among them *Dioscorea*, were experimented with. Success attended the experiment both in simple-leaved *Dioscoreas* and in those with compound leaves.



3. *Stenoglottis longifolia*.

2. *Dioscorea*.

1. *Acalypha Wilkesiana*.

Material was insufficient for detailed anatomical investigation, but the growth form of the new plant is interesting (fig. 2). It consists of a swollen tuberous portion attached to the parental leaf. The tuber bears numerous fibrous roots. No leaves are formed in the first year, the parental leaf being the sole photosynthetic organ of the developing plant. On the death of this leaf the tuber forms the perennating organ for the new plant.

Root propagation of *Stenoglottis longifolia*, an orchid, presents several features of interest. Propagation is most successful from roots showing constricted areas if these roots are severed at the constriction. Callus originating from the parenchymatous cortex of the root develops. This callus in horizontally placed cuttings develops towards the upper side of the horizontal root. On the upper side of this callus, buds are produced, originating from all groups some distance below the surface (fig. 3). Vascular connection between the developing bud and the root is supplied by short spiral tracheids which link up the new plant with the old root.

ANOMALOUS STEM STRUCTURE IN *RUSCUS ACULEATUS*
LINN. By HAMISH BOYD GILLILAND.

(Read 21st May 1931.)

Ruscus aculeatus Linn. (Lond. Cat. Brit. Plants (1925), No. 1850) is a rhizomatous shrub. New shoots from the rhizome

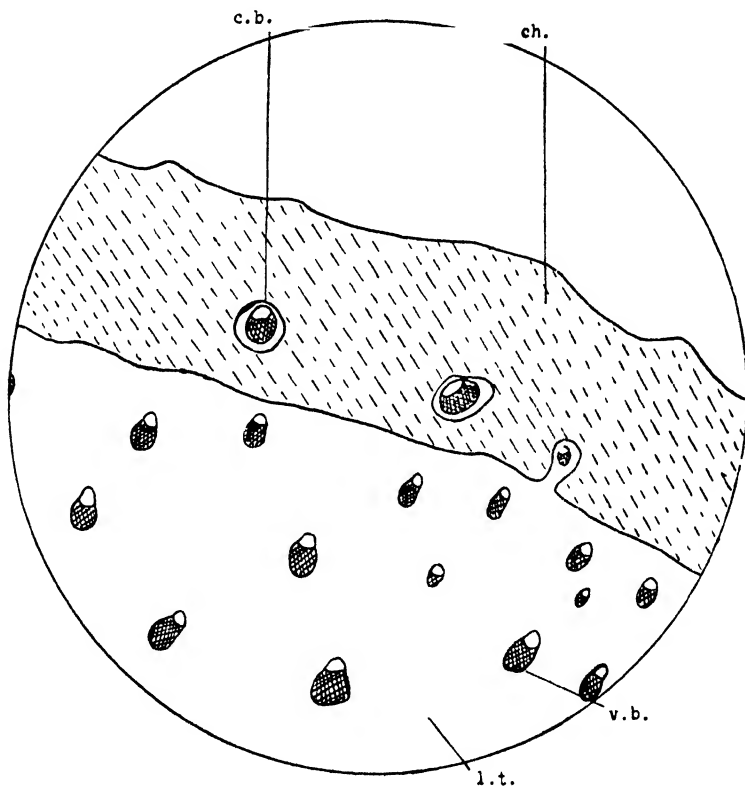


FIG. 1.—Portion of a section of mature stem of *Ruscus aculeatus* Linn.
c.b. = cortical bundle; ch. = chlorenchyma; l.t. = lignified tissue;
v.b. = vascular bundle.

appear above ground in May and these shoots flower in the following spring.

The axes of these flowering shoots consist of a hollow cylinder of chlorenchyma surrounding a central solid cylinder

of lignified cells in which the bundles of the vascular system are dispersed. The epidermis is strongly cuticularised.

In some cases (fig. 1) in the cylinder of chlorenchyma complete vascular bundles are present which either, after their course through this cortex, pass to a lateral appendage or rejoin the central lignified cylinder.

Sections of a young bud show the lignification to be confined to the protoxylem, later to have spread to metaxylem, but it is not till a very late stage that the central cylinder of lignified cells differentiates from the ground tissue.

The plant is structurally a xerophyte, leaves being reduced to scales, branches modified as phylloclades, and the general cortical tissue consisting of chlorenchyma.

The development of chlorophyll in the cortex precedes the lignification of the central cylinder, and it is suggested, in some cases, by penetrating the distal layers of what would normally differentiate as the central cylinder, inhibits there the process of lignification, leaving some peripheral bundles surrounded by a non-lignified tissue.

Similar inhibition by preformation of chlorenchyma would apply to non-lignification in homologous regions of the cladode.

The anomaly therefore rests not so much in the "cortical" position of the bundles of the vascular system as in the distribution of the lignified and chlorenchymatous tissues.

The sequence of events in the differentiation of these two tissues is being investigated in greater detail.

EVOLUTION IN THE MONOCOTYLEDONOUS SEEDLING : A NEW
INTERPRETATION OF THE MORPHOLOGY OF THE GRASS
EMBRYO. By LUCY BOYD, D.Sc.

(Read 18th June 1931.)

The structure of the grass embryo still remains the most controversial question in seedling morphology. The present publication deals briefly with the matter from a new standpoint. One result of a research extending over four years on monocotyledonous seedlings has been the acquiring of information not available to previous writers formulating theories on the embryo of Gramineae. Observations on the seedlings of a large number of genera have led the author to the conclusion that seedlings of the phylum are apparently subject to certain trends. In order that a general perspective be obtained, a discussion of the latter will form an introduction to the treatment of the grass embryo in particular. The evidence on which the following views are founded will, it is hoped, be published in full at an early date.

TENDENCIES OF MONOCOTYLEDONOUS SEEDLINGS TOWARDS
AN ADVANCED TYPE.

(a) *From the Epigeal to the Hypogeal Habit.*—This tendency is suggested by a consideration of those families retaining epigeal germination and of the numerical relationship between the two types. Morphologically, epigeal and hypogeal seedlings are identical. There is a physiological distinction in that the former have cotyledons which manufacture food in addition to conducting it. Schlickum (17) has commented upon the advantages of hypogeal germination, namely, added protection to the plumule and more effective anchorage of the seedling.

(b) *Towards Earlier and Stronger Plumular Development.*—Unless endosperm is plentiful, the early appearance of photosynthetic organs is an urgent necessity.

(c) *From the Non-ligulate to the Ligulate Type of Cotyledon.*—The origin of the ligule, a closed tube of varying length en-

sheathing the plumule. has been already discussed by Schlickum (17), Sargent and Arber (15). Its significance as an organ for the protection of a rapidly developing plumule is apparent. Certain families, *e.g.* Commelinaceae, are at a transition stage, while the greater number of species with a ligulate cotyledon occur in the most advanced families (fig. 1).

(d) *Towards Decreasing Importance of the Radicle.*—Seed-

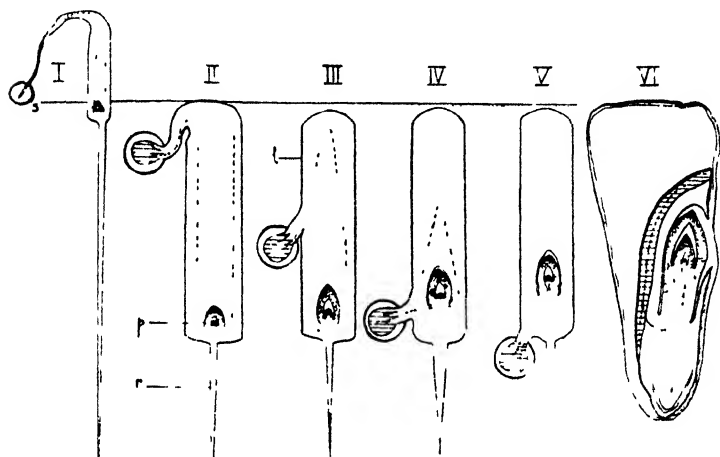


FIG. 1, i-vi.—Series of monocotyledonous seedlings indicating a gradual transition from a simple epigeal type (i) to a pronounced hypogeal ligulate type with consequent reduction in the length of the cotyledon strands (indicated by dotted line). Intermediate stages are shown in such instances as the Commelinaceae (iii). The grain of *Arena sativa* (vi) shows intra-seminally the differentiation and orientation of organs exhibited by the seedlings of the Zingiberaceae (iv) and (v). (Diagrammatic.)

p = plumular bud.
s = surface of soil.

r = radicle.
l = ligule of cotyledon.

lings having ligulate cotyledons usually exhibit advanced differentiation and rapid growth of the plumule. In such the radicle tends to be increasingly dominated by the latter until extreme cases occur where the primary root does not appear as a distinct organ. Two suggestions regarding such a limitation may be made. The quantity of raw material and space at the disposal of the embryo is to a certain extent fixed. Marked development of one organ, such as the plumule, will take place at the expense of another. Further, the rapid production of foliage leaves results in a strain on the vascular

supply of a single primary root incapable of secondary thickening. There is a consequent need for an adventitious root system.

(e) *Towards Economy in the Vascular System of the Cotyledon.*—From a study of the anatomy of monocotyledonous seedlings it appears to the writer that the vascular tissue of the cotyledon is disappearing. A lengthy reduction series can be traced from seedlings of relatively primitive families with many cotyledonary strands, through the central Liliaceous type with a double bundle or single strand, to the extreme case in which the cotyledon is almost completely devoid of vascular tissue. A complete consideration of such a series and its relation to Sargent's widely accepted theory of the origin of the seed leaf of monocotyledons (14) does not lie within the scope of the present discussion. Three instances will be furnished of genera in which the cotyledon has apparently lost almost its entire vascular supply in order that direct communication may be established between the plumular bud and the suctorial tip imbedded in endosperm.

(f) *Towards Increasing Embryonic Development before Germination.*—This tendency is parallel to the gradual acquisition of a ligulate cotyledon, and affects not only the differentiation of the organs, but their relative orientation. In epigeal germination the cotyledon, plumule and radicle of the seedling finally lie in the same vertical straight line (fig. 2, 5a, 5b); the same is true in hypogeal germination, but the cotyledon tip and stalk are not in alignment with the other organs.

FIG. 2.—1. Embryo of *Avena sativa* in longitudinal section. The missing portion of the ligule between epiblast and ventral scale is indicated by a double dotted line. 2. Seedling, one week old, of *Hedychium Gardnerianum*, for comparison with *Avena*. 3. Ripe embryo of *Bambusa arundinacea*, in longitudinal section, showing primitiveness, since it attains in its ontogeny a stage comparable with the embryo of *Billbergia zebrina* (6a) (sketched from a preparation by W. E. Evans). 4. Young embryo of *Oryza sativa* in longitudinal section (after Bruns). 5a, 5b. Germination of a simple epigeal monocotyledonous seedling, the axis of the organs being in a vertical line. 6. *Billbergia zebrina*. a. Ripe embryo; compare orientation of organs and vascular anatomy with that of *Bambusa*. b. Seedling two days old. c. Seedling ten days old; the final orientation of sucker root and shoot has been reached at this stage, cf. embryo of *Avena sativa*.

c = cotyledon.
e = epiblast.
en = endosperm.
l₁ = first leaf.

lig = ligule.
mes = "mesocotyl."
r = radicle.
r' = adventitious root. v.s. = ventral scale.

s = sucker.
sc = scutellum.
t = testa.

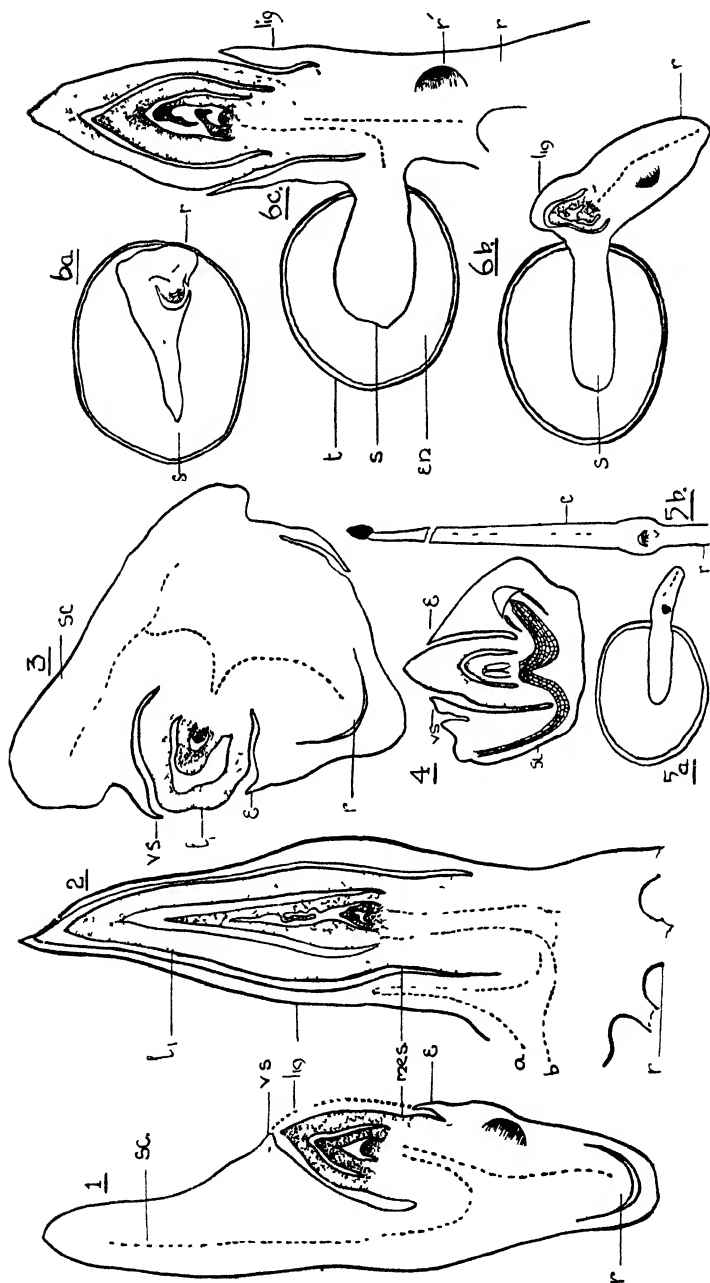


FIG. 2.

Where the cotyledon is ligulate, however, the vertical line in which plumule and radicle lie is at right angles to the cotyledon stalk and sucker (fig. 2, 6c). This orientation reacts upon the intra-seminal condition. Not only are the plumule and radicle out of alignment with the remainder of the embryo, but they lie at an obtuse angle to each other (fig. 2, 6a). The form of the post-seminal plant appears to be foreshadowed in the seed.

The culmination of all these tendencies is to be found in the Grass Embryo and Seedling.

PREVIOUS HISTORY OF RESEARCH ON THE GRASS EMBRYO.

The grass embryo has been so often described that another account of it would be superfluous. The opinions of different investigators on the organs in dispute will, however, be summarised.

(i) *The Scutellum*.—This fleshy, shield-like structure (fig. 2, 1) is now commonly admitted to be a haustorial organ, the equivalent of the suctorial part of the cotyledon. It has been interpreted at different times as an absorptive organ, as the tegument of the endosperm, as a haustorial organ, not, however, morphologically equivalent to the cotyledon, or as part of the single cotyledon of which the remaining portion is the coleoptile.

(ii) The term *coleoptile* designates the sheath of the plumule. It has been regarded as the single cotyledon or its expanded part. Schleiden (16) supposed it a primordial leaf succeeding the cotyledon; Van Tieghem (18) believed it to originate from the union of a pair of stipules belonging to the cotyledon proper, represented by the scutellum, while Schlickum considered it exactly comparable to the ligule of the cotyledon as seen in other monocotyledons.

(iii) *The Epiblast* is a parenchymatous, non-vascular, leaf-like structure, which, if present, arises opposite to the scutellum. It has been described as a rudimentary second cotyledon, as a prolongation of the scutellum, as part of the cotyledon sheath, or, since it possesses a downward extension, part of the coleorhiza or sheath of the primary root. Celakovsky (3) compares the cotyledon to the adult foliage leaf

of the grasses, the epiblast being equivalent therefore to a pair of fused auricles.

(iv) *The Mesocotyl*.—The strongest argument against the ligulate nature of the coleoptile is that in certain genera a region produced by intercalary growth separates what is regarded as the two parts of the cotyledon, namely, scutellum and ligule. To this intercalary portion the term mesocotyl was therefore applied. Further, it is traversed by cotyledonary and plumular strands.

Its significance is a matter of more recent discussion. Van Tieghem, by a "bold morphological fiction" (18, p. 164), described it as a lengthened node. Celakovsky, arguing from developmental evidence, held the same view, while Bruns (2), basing his theory entirely on external appearances, regarded it as the first internode of the plumular axis, an opinion revived within recent years by Coulter (4). The latter, whose views were coloured by his findings in an anatomical investigation of a dicotylous *Agapanthus*, demonstrated that in grasses a remarkable number of transition stages from dicotyledony to monocotyledony were to be found. The epiblast, then, represented a second cotyledon; the mesocotyl between the two "cotyledons" was therefore the first internode of the plumule. Coulter's conclusions were criticised by Worsdell on two grounds, namely, that they were based on external morphology and with an entire disregard for previous publications on mesocotylar anatomy. Worsdell's own theory, which was founded on a comparative morphological treatment of the seed leaf and the adult foliage leaf, does not account satisfactorily for the vascular structure of the mesocotyl.

Sargent and Arber's Memoir of 1915 (15) proposed a theory commonly accepted as being in accord with the anatomical facts. From a consideration of a series of ligulate seedlings, the idea was conceived of the cotyledon stalk becoming so closely adpressed to the sheath that finally a fusion, affecting the cotyledon stalk and hypocotyl, occurred. The resulting structure, the mesocotyl, was therefore partially cotyledonary in its nature.

The investigators in this instance were led to a theory by the anatomical resemblance between the coleoptile and the typical ligule of the monocotyledonous seedling. The facts concerning the mesocotyl were made to fit a theory which

would allow the coleoptile, with its two strands derived from the cotyledon, to be homologous with such a ligule. The theory would seem to suffer from other defects. It rested on somewhat insufficient evidence. A very thorough research was made on numerous grass seedlings, but the theory was founded chiefly on the vascular skeleton of six genera of Zingiberaceae. In four of these the two cotyledon strands entered the ligule, but in *Alpinia* the upper bundle, when it entered the sheath, only penetrated it for a short distance, and in *Brachychilum* the ligule contained no bundles whatever. The exact course of the strands which did not enter the ligule in *Alpinia* and *Brachychilum* was not fully described. The fact that the ligule of the latter could be non-vascular ought possibly to have been disadvantageous to its use as evidence for the nature of the two-stranded coleoptile: no such objection seems to have been raised. The theory lacked simplicity to a certain degree. Explanations of certain structures had to be made, often with difficulty, for the sake of conformity with the theory, while it left the nature and variability of the epiblast unexplained. Howarth, in 1927, found confirmation of Sargent and Arber's theory in his research on *Festuca rubra* (12).

Percival (13) believes that scutellum, epiblast, coleoptile, and first green leaf of the grass seedling are the first four leaves of the plant. He makes no attempt to reconcile the anatomical facts with this view and fails to appreciate what Sargent so clearly demonstrated—that the key to the interpretation of the grass embryo was to be found, not in itself, but in the structure of a seedling, the nature of whose organs was in no way obscure.

THE GRASS EMBRYO AS A FINAL STAGE IN AN EVOLUTIONARY SEQUENCE.

Orientation of Organs in the Embryo.—The germination of a typical ligulate seedling exhibits two phases. In the first, the embryo elongates and emerges without cell division, the axis of the plumule lying at an obtuse angle to that of the radicle: this phase may be regarded as the completion of the maturation of the embryo (fig. 2, 6a, 6b). The final orientation of the organs of such a seedling occurs in the second

phase, three or more days later, when the axes of radicle and plumule lie in a vertical straight line (fig. 2, 6c), which is at right angles to the suctorial portion of the cotyledon enclosed in the seed. Differentiation has proceeded so far before germination in many genera of the Gramineae that the first phase does not occur; the parts of the embryo have already changed to the relative positions of the second phase, and a stage in development normally occurring post-seminally is attained within the seed (fig. 1, vi). These observations on the orientation of the embryonic organs were previously made by Gatin (6, 7), whose work on seedling anatomy has been almost entirely ignored by later investigators. He apparently recognised neither the significance of his findings, nor the fact that the grass embryo repeats in its intra-seminal ontogeny the sequence followed in the early post-seminal development of ligulate seedlings belonging to other monocotyledonous orders.

Relative Development of Organs in the Embryo. - The remarkable development in the grass embryo of the plumule and the adventitious root system, taken in conjunction with the pronounced endogeny and poor differentiation of the radicle, is in accordance with the opinion that it belongs to an advanced type. The cotyledon affords striking evidence of this view. Reduction has affected it to such an extent that it now consists of

(i) a suctorial portion, the "scutellum," and, in certain species,

(ii) a fragment of the sheathing base, hitherto termed the epiblast.

The cotyledon is entirely non-vascular except for the scutellum traces. Its strands have become part of the vascular system of the first internode of the plumular axis, the so-called mesocotyl. The cotyledon possesses no distinct organ that can be termed a ligule: the "coleoptile" is therefore the first plumular leaf. The basis for this view is revealed by a comparison of certain grass seedlings, described by Sargent and Arber, with seedlings of *Billbergia zebrina* (Bromeliaceae) and of two genera of Zingiberaceae, namely, *Hedychium Gardnerianum* and *Alpinia calcarata*. The three genera have seedlings of the ligulate type. It is not proposed

in this paper to describe fully the phenomena of germination and the external morphology of these seedlings. An account

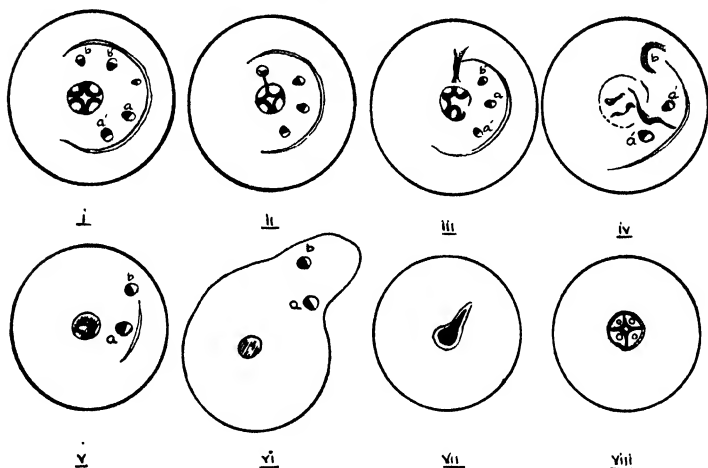


FIG. 3.—*Alpinia calcarata*. Series of transverse sections through seedling two days old. viii. Primary root. vi. Two cotyledon strands proceeding through the stalk. iv. Strand *a* branches, giving two strands, *a'*, to the first leaf, the remainder being directed inwards to the meristem of the second leaf. i. Base of the first leaf, of which the total vascular tissue is derived from the greater part of the cotyledon strands.

is given of the anatomy only in so far as it has a bearing on the elucidation of the problem of the grass embryo.

Comparison of Certain Ligulate Seedlings with Types of Grass Embryo.

A. Alpinia calcarata (fig. 3).

1. Two strands leave the suctorial tip of the cotyledon, proceed through stalk, and at the base of plumular axis each ramifies, giving three traces (fig. 3, iv).
2. The axis has a central core consisting of plumular traces plus one-third of each cotyledon strand. The latter supply the second leaf. An outer ring of four strands derived from the cotyledon supplies the first leaf (fig. 3, i).
3. The first leaf derives its total vascular supply from the cotyledon strands.

Sorghum vulgare.

1. A single strand proceeds from the "scutellum" straight to the base of the "mesocotyl."
2. The stele of the "Mesocotyl" consists of two "coleoptile" traces (distinctly double) plus plumular traces. Part of the scutellum trace forms half of each coleoptile trace at the top of mesocotyl. The remainder is prolonged downwards towards the root.
3. The "coleoptile" (*i.e.* first leaf) derives its total vascular tissue from the cotyledon.

B. Billbergia zebrina (fig. 4).

1. A single cotyledon strand proceeds from the tip, through the stalk (fig. 4, vii).
2. It ascends the first internode in an independent peripheral position (fig. 4, iv).
3. Towards the top it merges into the meristem of the first leaf, contributing to the lateral strands (fig. 4, i).
4. Longitudinal sections reveal the presence of a bridge comparable to that in *Avena*.

C. Hedychium Gardnerianum (fig. 5).

1. Two strands are found in the cotyledon tip.
2. One strand proceeds horizontally to base of plumular axis, where it divides —
 - i. half maintains an independent peripheral position to the top of the internode, where it merges into the meristem of the lateral strands of the first leaf and the mid-rib of second leaf;
 - ii. half enters the central stele of the axis.
3. The first leaf laterals and possibly the mid-rib of the second leaf are derived from half of the cotyledonary tissue.

Avena sativa.

1. There is a single scutellum trace.
2. It ascends the "mesocotyl" as an independent peripheral strand.
3. At the top of the mesocotyl it forms part of the complex from which the two "coleoptile" strands, laterals of the "first" leaf and mid-rib of the "second" leaf, arise.
4. The top of the scutellum trace is connected to the central stele by a xylem "bridge" or "arch."

Represents a compromise between *Avena* and *Sorghum* in the occurrence

- (a) of an independent peripheral scutellum trace;
- (b) of a portion of the scutellum trace becoming part of the central axis of the first internode.

Conclusions drawn from above Comparison.

1. The occurrence of cotyledon traces, independent or otherwise, in the first internode of the plumular axis is a feature that can no longer be associated with Gramineae alone. The need for a hypothetical mesocotyl in the grasses does not therefore exist.

2. Leaf-like organs drawing their vascular supply wholly or partly from the cotyledon are not necessarily to be regarded as cotyledonary in nature. The plumular origin of the first foliar member of *Alpinia calcarata*, which exactly homologises with the "coleoptile," is indisputable.

3. The grass seedling has now no "ligule," but its cotyledon

was formerly identical with that of the *Hedychium* type, consisting chiefly of ligule, with the stalk inserted so low that almost no sheathing base was present.

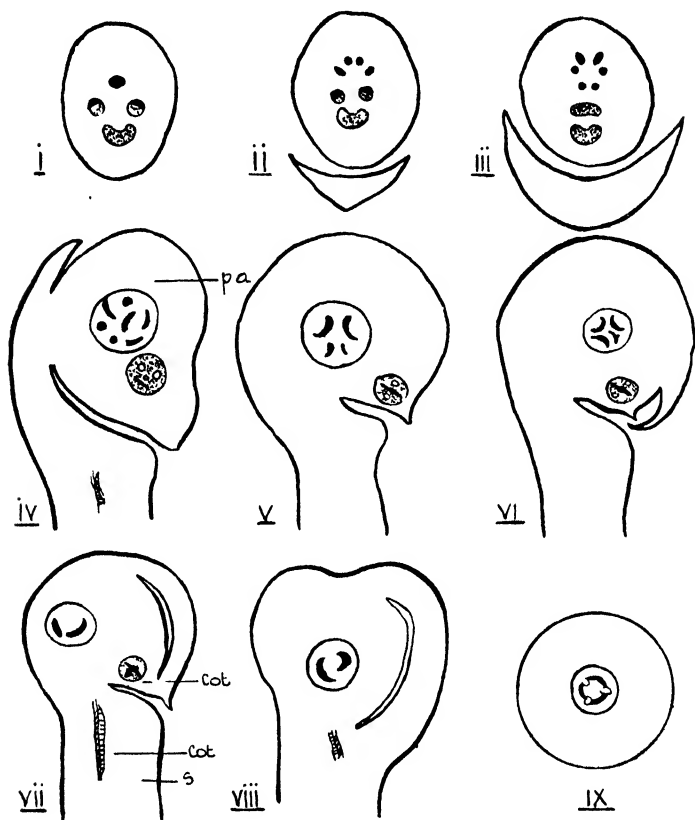


FIG. 4.—*Billbergia zebrina*. Series of transverse sections through young seedling. ix. Primary root. iv-viii. Cotyledon strand (*cot.*) proceeds through the short stalk (*c.s.*) and enters the plumular axis. i. Axis towards base of the first leaf. (The cotyledon strand may bend upwards in passing to the axis, hence it may appear twice in the same transverse section.)

*Derivation of the Grass Cotyledon from that of the
Hedychium Type.*

1. Tangential pressure on the club-shaped sucker of *Hedychium* will produce the fleshy plate (scutellum) of the grass.

2. As a result of the same force the short stalk (almost non-existent) in *Hedychium* will completely disappear.

3. If, in *Hedychium*, that side of the ligule remote from the sucker becomes thinner, until finally in the weakest region the tissue ceases to develop, only a fragment (the epiblast) will persist on one side. The other side of the ligule will be contiguous with the sucker, with which it will, therefore, fuse. The plasticity of the latter will be advantageous for this union.

Evidence for such a derivation of the grass cotyledon is found in that organ itself.

(i) *The Epiblast* may be non-existent (*Zea*), a thin scale barely discernible, or a leaf-like organ clasping half round the "mesocotyl" and having its tip extended to the level of the base of the coleoptile (*Zizania aquatica*). In extreme cases (*Leersia clandestina*) the epiblast may reach almost to the tip of the coleoptile. Reduction has therefore progressed to varying degrees in the different genera. Van Teighem's research indicates that two-thirds of the grasses have an epiblast, while Bruns's tables on the frequency with which it occurs reveal an interesting sequence. With the exception of the *Oryzaceae*, tribes of Hackel's first series have, as a rule, embryos with no epiblast. It is found with very few exceptions in the remaining tribes. These comprise Hackel's second series, which, according to Bews (1), contains most primitive forms. *Hordeum* and *Triticum* at the end of the second series have two strands in the cotyledon and an epiblast. The relatively advanced *Zea Mays* at the beginning of the first series has no epiblast, and only one vascular strand: it thus appears as the final stage in the gradual loss of the ligule and reduction of vascular tissue.

(ii) In certain instances the orientation of the ripe embryo is only slightly in advance of that of the *Hedychium* type. Epiblast and scutellum are then of equal length (giving an appearance which misled Coulter to a discovery of "dicotyledony"). A bridging of the short gap between them would complete the ligule (fig. 2).

It is interesting to note that stages comparable to this occur in the early ontogeny of the advanced types. Further differentiation and growth of the embryo result in a widening of the distance between the two parts of the cotyledon.

(iii) The remainder of the non-vascular ligule, in fusing with the flat sucker, lost its identity almost completely. An indication of its former separate existence is given by the short overhanging protuberance at the upper limit of the scutellum, sometimes designated "the ventral scale." (Percival, regarding the scutellum as a foliage leaf, terms it "the ligular scale.") Like the epiblast, its development is variable. It is very marked in the floristically primitive *Bambusa*, a genus of which the embryo is ontogenetically backward (fig. 2). In embryos with large epiblasts it seems to be prominent, but frequently does not appear where the former is missing. A very significant figure of an immature embryo of *Oryza sativa* by Bruns shows a deep cleft occurring between the outer layer of the scutellum and the lengthy protuberance (fig. 2). The ventral scale evidently represents the apex and often, in addition, part of the aborted portion of the former ligule, which is now limited to the epiblast and to the inner layer of the scutellum. The outer layer of the latter was the sucker; it includes the vascular tissue and is bounded by the epithelium. The sucker in its original form may not have been necessarily club-shaped as in *Hedychium*. *Musa*, for example, has a sucker shaped like a plate.

*Probable Factors in Determining the Configuration
of the Cotyledon.*

1. A balance is maintained between the embryonic organs. Inordinate development of the plumule seems to have an effect on the radicle. It may in addition react adversely on the cotyledon.

2. The mature embryo represents a phase which in other monocotyledons takes place post-seminally. Unlimited expansion would normally be available. The firm pericarp and mass of endosperm place restrictions upon a body in a plastic condition, and were probably the most potent factors in altering the shape of the cotyledon. As would be supposed, distortion from the normal *Hedychium* type is least in the very early stages.

3. The position of the embryo in the seed accounts for its shape. Subjected to pressure from the endosperm side, the organs most affected will be

- (i) the sucker and the half of the ligule on that side ;
- (ii) the portion of the ligule forced against the testa. The lack of endosperm in this neighbourhood and the

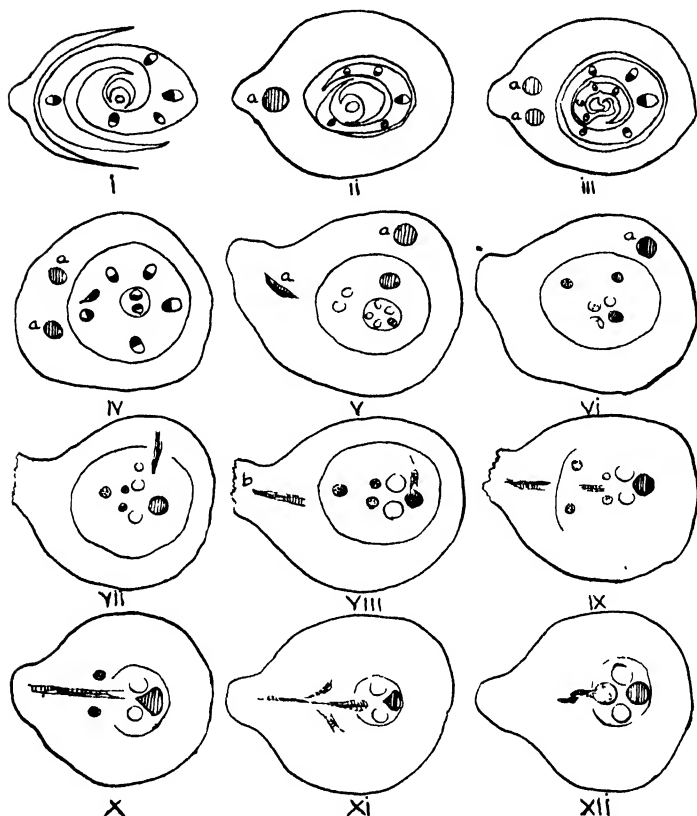


FIG. 5.—*Hedychium Gardnarianum*. Transverse section of seedling six days old from hypocotyl to the plumular bud. i. Plumular bud and tip of ligule. ii. Tip of cotyledon strand *a* where it bends downwards (see fig. 2, 2). iii. Upward and downward traces of strand *a* passing through the ligule. iv. Strand *a* proceeds through the stalk of the cotyledon towards the sucker. v. The other end of strand *a* as an independent trace; it now enters the plumular axis. viii. Strand *b* proceeds outwards from the seed through the stalk. ix-xii. Strand *b* enters the axis. xii. Upper limit of hypocotyl. The four groups of vascular tissue rearrange themselves to supply a tetrarch stele in the primary root.

downward extension of the epiblast in certain embryos are thereby explained.

The apex of the radicle and of the ligule will be least affected.

The vestigial remains of the latter have therefore persisted as "the ventral scale."

The coleorhiza does not merit a discussion; its existence is clearly the result of the endogeny of the radicle.

Possible Criticisms of the Foregoing Argument.

(i) That the venation of the coleoptile is inconsistent with that of an independent plumular leaf. (Used by Worsdell of Coulter's Theory.)

The first scale leaf of *Romulea ramiflora* (Iridaceae) and the coleoptile are identical in venation.

(ii) That there exists a greater difference between the coleoptile and the "first leaf" than between the latter and succeeding leaves. (Worsdell criticising Coulter.)

This argument is refuted by observations on monocotyledonous seedlings over a sufficiently wide field. The first foliar organ has frequently a shape and venation simpler than for succeeding leaves, while certain groups, *e.g.* the Zingiberoideae, provide excellent examples of second and third plumular leaves being also of the nature of scale leaves.

(iii) That Hegelmaier and Hanstein observed that "the rudiments of the coleoptile arise in the tissue complex which is becoming the scutellum." (Worsdell.)

In a similar manner the first leaf of any monocotylous embryo would appear to arise from the surrounding cotyledon tissue. The distortion in the plumular region of the embryo, and the lack of cotyledonary tissue to sheathe the bud, has obscured the true origin and nature of the "coleoptile."

(iv) That no instance can be cited in which the gap between the epiblast and the ventral scale is actually bridged.

A line of future research is suggested by this criticism. The search for an embryo showing such a fusion may be fruitless since the gap in the ligule possibly corresponds to a slit such as occurs in numerous cotyledons for the emergence of the first leaf.

The Position of the Present Theory in Relation to Previous Interpretations of the Grass Embryo.

1. In its conception of the nature of mesocotyl and coleoptile, it is akin to that of Bruns and Coulter, but the latter accepted the plumular nature of these organs as a corollary to their belief that the epiblast was a second cotyledon and not on anatomical grounds.

2. It accounts in a consistent manner for the epiblast and ventral scale where these occur, and for their absence in the advanced types. That the epiblast is a scutellar outgrowth (3) or foliar organ such as occurs at the base of the axis of *Sedum* (Celakovsky) is incompatible with its position, which would inhibit the production of new structures.

3. The difficulties which had to be explained away by Sargent and Arber on their assumptions no longer arise; for example, the anatomical difference between the "mesocotyl" of *Sorghum* and *Avena*, the absence of mesocotyl in *Hordeum* and *Triticum*, and the "xylem arch" at the top of the mesocotyl in *Avena*. The bud axillary to the coleoptile which Howarth found in *Festuca rubra* no longer calls for comment: it is merely in the axil of a plumular leaf.

4. The necessity for the phylogenetic relationship between *Zingiberaceae* and *Gramineae*, suggested by Sargent and Arber (15, p. 219), to explain similarity in seedling structure, does not exist, since the Grass type of "mesocotylar" anatomy occurs in *Bromeliaceae* as well as in *Zingiberaceae*. A more striking example of parallel development would be difficult to find.

5. The grass embryo regarded from the new standpoint is in closer conformity with the general monocotyledonous type than hitherto.

SUMMARY.

1. A brief survey of apparent evolutionary trends in the seedlings of monocotyledons indicates that the main tendency is towards precocious development of the plumule, abortion of the radicle, and consequent importance of an early adventitious root system. The vascular tissue of the cotyledon is disappearing, a phenomenon illustrative of convergent

evolution, since it is found in families which differ widely in phylogeny. Such trends are included in the possible factors which have determined the configuration of the grass embryo.

2. An historical account of previous views on the morphology of the embryo and seedling in the Gramineae is followed by a comparison of certain types of grass embryo, described by Sargent and Arber, with seedlings of three genera investigated by the writer.

3. A new theory having for its basis the anatomical evidence provided by the latter seedlings places the following interpretation on those organs of the grass embryo at present in dispute :

The *scutellum* is a double structure consisting of (i) a vascular plate bounded by the epithelium and equivalent to the suctorial tip, in contiguity with (ii) an inner non-vascular plate which is adpressed to the embryonic plumular organs and is equivalent to part of the cotyledonary ligule.

The *epiblast* is a fragment of the sheathing base of the cotyledon and of that side of the ligule which has disappeared.

The *ventral scale* is the vestigial remnant of the apex of the ligule of the cotyledon.

The *mesocotyl* is the internode separating cotyledon and first leaf. Its origin and nature are purely plumular, though its vascular tissue may at first be wholly or partially derived from the cotyledon. The term "mesocotyl" is not only unnecessary but misleading.

The *coleoptile*, like the mesocotyl, is a plumular organ, and is equivalent to the first foliage leaf : it is a scale leaf in its appearance. The so-called "first leaf" is actually the second plumular leaf of the seedling.

4. Further evidence for the theory, possible criticisms of it, and its position in relation to the opinions of previous investigators are then discussed.

The writer wishes to acknowledge her indebtedness to Professor W. Wright Smith, Regius Keeper of the Royal Botanic Garden, Edinburgh, for facilities for the present study, and to his University and Garden staff.

BIBLIOGRAPHY.

- (1) BEWS, J. W. : Studies in the Ecological Development of Angiosperms. New Phyt., xxvi, 1927.
- (2) BRUNS, E. : Der Grasembryo. Flora, lxxvi, 1892, p. 1.
- (3) CELAKOVSKY, L. J. : Über die Homologien des Grasembryos. Bot. Zeit., lv, 1897, p. 141.
- (4) COULTER, J. M., and LAND, W. J. G. : The Origin of Monocotyledony. Bot. Gaz., lvii, 1914, p. 509.
- (5) COULTER, J. M. : The Origin of Monocotyledony. II. Monocotyledony in Grasses. Ann. Mo. Bot. Gard., ii, 1915, p. 175.
- (6) GATIN, C. L. : Recherches Anatomiques et Chimiques sur la Germination des Palmiers. Ann. Sci. Nat. Bot., sér. iii, 1906, p. 191.
- (7) ———— Recherches Anatomiques sur l'Embryon et la Germination des Cannacées et des Musacées. Ann. Sci. Nat. Bot., sér. 9, viii, 1908, p. 113.
- (8) ———— La Morphologie de la Germination et ses Rapports avec l'Anatomic. Rev. Gén. Bot., xx, 1908, p. 273.
- (9) ———— La Morphologie de la Germination et ses Rapports avec la Phylogénie. Rev. Gén. Bot., xxi, 1909, p. 147.
- (10) HANSTEIN, J. : Entwicklungsgeschichte der Keime der Monokotyledonen und Dikotyledonen. Bot. Abhandl. Bonn, 1870, p. 112.
- (11) HEGELMAIER, F. : Zur Entwicklungsgeschichte monokotyledoner Keime. . . . Bot. Zeit., xxxii, 1874, p. 631.
- (12) HOWARTH, W. O. : The Seedling Development of *Festuca rubra* var *tenuifolia* and its bearing on the Morphology of the Grass Embryo. New Phyt., xxvi, 1927, p. 46.
- (13) PERCIVAL, J. : The Wheat Plant, 1921.
- (14) SARGANT, E. : A Theory of the Origin of Monocotyledons, founded on the Structure of their Seedlings. Ann. Bot., xvii, 1903, p. 1.
- (15) SARGANT, E., and ARBER, A. : The Comparative Morphology of the Embryo and Seedling in the Gramineae. Ann. Bot., xxix, 1915, p. 161.
- (16) SCHLEIDEN, M. J. : Einige Blick auf die Entwicklungsgeschichte des vegetabilischen Organismus bei den Phanerogamen. Wiegmanns Archiv, i, 1837, p. 289.
- (17) SCHLICKUM, A. : Morphologischer und anatomischer Vergleich der Kotyledonen und ersten Laubblätter der Keimpflanzen der Monokotylen. Bibliotheca Bot., Heft 35, 1896, p. 1.
- (18) VAN TIEGHEM, PH. : Observations Anatomiques sur le Cotylédon des Graminées. Ann. Sci. Nat. Bot., sér. 5, xv, 1872, p. 236.
- (19) WORSDELL, W. C. : The Morphology of the Monocotyledonous Embryo and of that of the Grass Embryo in particular. Ann. Bot., xxx, 1916, p. 509.

A complete list, in chronological order, of the principal papers on the embryo and seedling of the Gramineae will be found in the bibliography of Sargent and Arber (15) and Worsdell (19).

NOTES ON SALT-MARSH PLANTS. I. *GLAUX MARITIMA* LINN.
By MARGARET A. MOIR, B.Sc.

(Read 18th June 1931.)

Glaux maritima L. is a small succulent herbaceous perennial of sub-prostrate habit. It is common on salt marshes and other parts of the seashore on British coasts, and is found in habitats which differ widely in their edaphic factors. The hydrogen ion concentration of the soil varies very little, being between 6·7 and 7·1, rather more acid than alkaline; on the other hand, the water content and physical nature of the soil vary considerably. Plants were examined from dry sandy soil on the cliffs; also from salt- and fresh-water marshes near the Eden estuary, where the soil was heavy clay and humus, and the water-content very high.

It was found that, correlated with the variations in the habitat, there are variations in the external morphology, and in the fertility of the plants. Those in the marshes show a much greater luxuriance of vegetative growth, and at the same time they flower scantily and set very little seed; while those in the drier habitats show a condensed growth form, and flower freely and set a large quantity of seed.

The phyllotaxy is normally cyclic, but tends to become irregularly spiral where rapid growth occurs; this tendency is especially noticeable in the marsh plants.

LEAF STRUCTURE.

The leaves are of two kinds, colourless kataphylls and green assimilatory leaves. In the former the mesophyll is undifferentiated and there is a central unbranched meristele; in the latter the venation is pinnate-reticulate, and the mesophyll is differentiated into palisade and spongy tissues, of which the former predominates, especially in the more apical leaves which show a tendency to the centric type of structure.

Irregular striations of the cuticle were observed, such as are recorded by Decrock ((1), p. 61), as a characteristic

feature of the family Primulaceae. No apical hydathode pore as described by Decrock (*loc. cit.*, p. 65) for the family was found in this type.

Stomata occur on both surfaces of the green leaf, being approximately one and a half times as numerous on the lower as on the upper surface. They are more sparsely distributed on the stem, and occur only rarely on the kataphylls. In the green leaves the guard cells are very small in comparison with the epidermal cells, and are slightly raised above them (fig. 1. *a*). The external walls have cutinised projections which meet above the stoma and protect it. The guard cells on the kataphylls are larger, and are just appreciably depressed below the level of the epidermis (fig. 1, *b*).

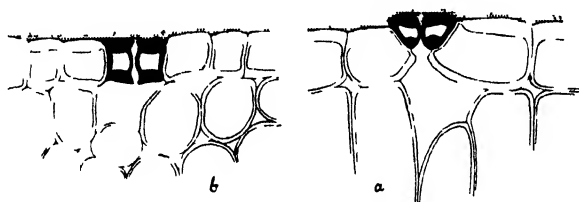


FIG. 1.

- a*. Transverse section through a stoma on the adaxial surface of a green leaf ($\times 300$).
b. Transverse section through a stoma on the adaxial surface of a kataphyll ($\times 300$)

Capitate glandular hairs, which, according to Solereder ((2), p. 503), produce a resinous secretion below the cuticle, occur on both surfaces of the leaf, more rarely on the kataphylls, and very rarely on the stem. Each hair consists of a basal cell, a stalk cell, and a head of four or more cells with prominent nuclei. On young organs the stalk and head of the hairs project; but when fully developed the hair is so deeply sunk in a depression that the head is below the surface (fig. 2, *a*, *b*, *c*).

In 1904, Zalensky formulated a new conception of xeromorphism in his quantitative anatomical investigations of different leaves of the same plant; later his work was independently confirmed by Yapp and others. The results of their work was to establish a general rule that the anatomical structure of individual leaves of one and the same shoot is a function of their distance from the root system; and the

higher a leaf is inserted on a stem, the more xeromorphic is its structure ((3), pp. 328-336). In order to ascertain how far the leaves of *Glaux maritima* conformed to Zalenky's hypothesis, several series of leaves, taken from different levels on the stem, were examined and measured. It was

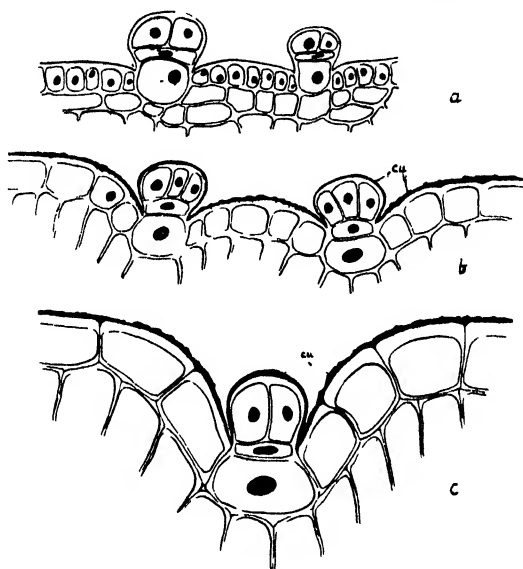


FIG. 2.

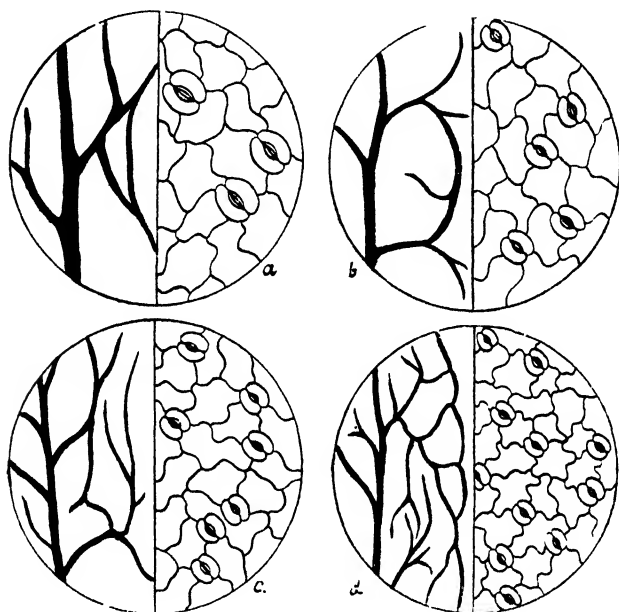
- a, Part of a transverse section of a young leaf, showing hairs projecting from the surface ($\times 300$).
 b, An older stage of the same ($\times 300$).
 c, Part of a transverse section of an adult leaf, showing one hair fully developed and sunk in a deep depression ($\times 300$). cu=cuticle.

found that in comparison with a leaf near the base of a stem, a leaf higher up near the apex has, in *Glaux maritima*,

- (1) smaller cells throughout the leaf ;
- (2) a larger proportion of palisade tissue (to such an extent that there is a tendency to the formation of palisade cells on the abaxial surface at the edges of the leaf) ;
- (3) a smaller proportion of spongy tissue ;
- (4) a thicker epidermis, the cells being deeper ;
- (5) thicker external walls of the epidermal cells ;
- (6) smaller stomata and more per unit area of leaf surface ;
- (7) smaller epidermal hairs and more per unit area of leaf surface ;

- (8) increased sinuosity of the epidermal cell walls ;
- (9) to a variable extent, increased density of venation, but this is not entirely constant throughout the series (fig. 3, *a*, *b*, *c*, *d*).

These results, with one exception, agree with those obtained by Zalensky, the exception being the increase in sinuosity of the



- a*. Diagram of the venation and epidermis of a leaf from a node near the base of the stem (venation $\times 55$; epidermis $\times 270$).
- b*. The same of a leaf four nodes higher.
- c*. The same of a leaf eight nodes higher.
- d*. The same of a leaf twelve nodes higher.

epidermal cell walls, Zalensky having recorded a progressive decrease in sinuosity from lower to higher.

STEM STRUCTURE.

The stem is green, smooth, and oval in section ; the direction of the long axis of the oval turns through a right angle at successive nodes, due to the passing out of the pairs of leaf traces (fig. 4). Throughout the internodes the outline of the

stem retains two longitudinal grooves, correlated with the deep impression made by the axillary buds at the node below. In length the stem varies from two to fifteen inches according to the habitat; the kataphyllary hypogeal region measures three-eighths of the whole. The procumbent tendency of the shoots leads to dorsiventrality, due to torsion of the leaves and secondary lateral branches.

Both outer and inner walls of the epidermis are thickened; there is a deep cortex of chlorophyllous cells which are elongated longitudinally. In the outer and middle cortex large intercellular spaces form continuous longitudinal air channels, which are interrupted at the nodes by nodal diaphragms several cells deep. A ring of sclerenchyma is developed round the stele by the lignification of the pericycle. Of eight primary collateral vascular bundles four are foliar and four are cauline. Secondary development of phloem is initiated very early, the phloem forming a continuous ring, while the eight xylem bundles remain quite distinct from each other; later a certain amount of secondary xylem is formed. In young stems the xylem parenchyma is chlorophyllous.

The stolons are similar in structure except that the intercellular channels are smaller. The stem apex is stratified; in the plerome there is a large central cell which is considered by Decrock to be the primary mother cell of the plerome. In the leaf primordia a similar large cell gives rise to both periblem and plerome (fig. 5).

ROOT STRUCTURE.

The root system of the adult plant is adventitious; the point of origin of the roots is definite and regular, they are developed from the stem just below a node, and they emerge on either side of the leaves. Four latent root primordia are present at every node; in a transverse section of the stem they appear as a diagonal cross, the arms of which radiate out from the stele (fig. 6).

The internodes at the base of the stem are much condensed, and at each of the three lowest nodes two or more of the root primordia remain latent; those which develop give rise to four or five long fleshy roots, which penetrate the soil to a maximum depth of nine inches, and are the main roots of the plant.

At the other nodes on the lower parts of the stem, and on

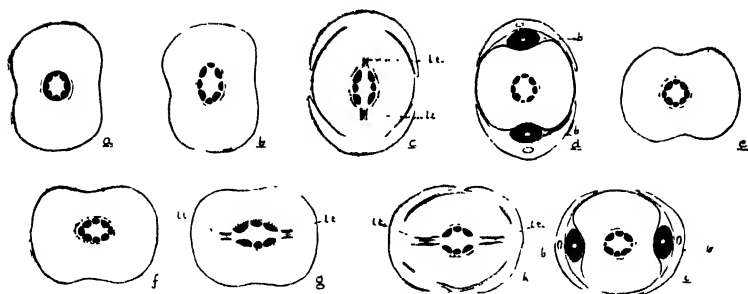


FIG. 4.—Diagrams of transverse sections of the stem, showing the changes in outline at successive nodes. lt. = leaf trace; b = bud.

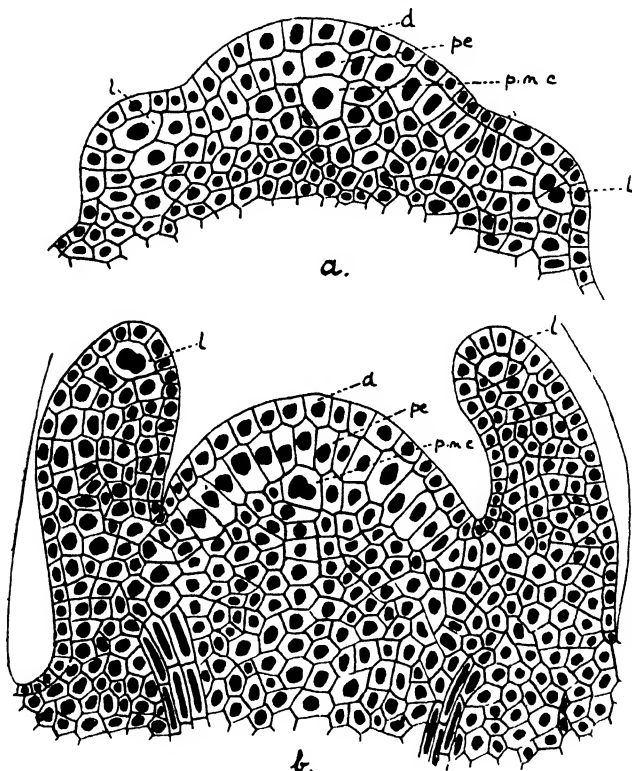


FIG. 5.

- a. Median longitudinal section of the apex of the stem, showing young leaf primordia ($\times 480$).
- b. Median longitudinal section of the apex of the stem, showing older leaf primordia and the clearly stratified apical meristem tissues ($\times 480$).
pe = perilem; d = dermatogen; p.m.c. = primary mother cell of the plerome; l = primary mother cell of the perilem and plerome of the leaf.

the stolons, all the primordia usually develop, resulting in four delicate roots per node. It was found that by further submerging young plants in soil or water, it was possible to induce the development of these roots as high up as the fifth node from the apical bud. Cuttings of young shoots rooted readily, but produced the short thin type of root only.

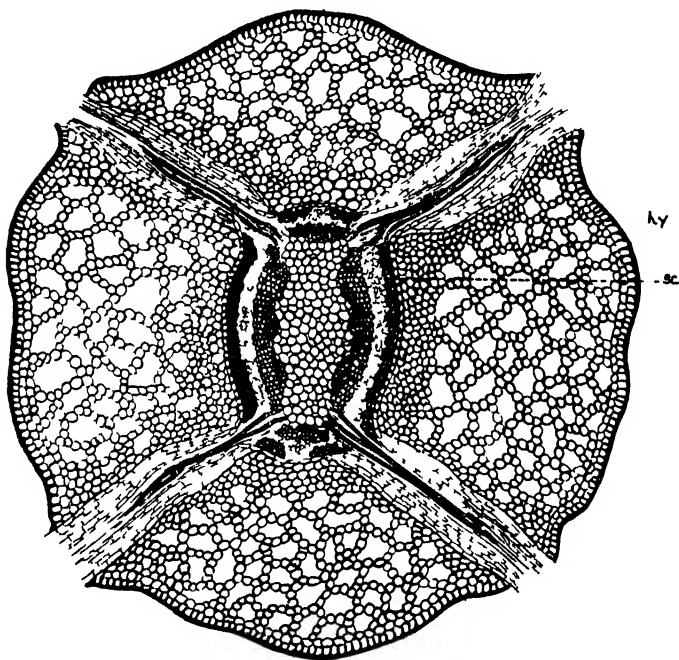


FIG. 6.—Transverse section of the stem near the base, just below a node, showing the origin of the four adventitious roots ($\times 32$).

The exodermis is double, both layers being suberised; the cortex is very large in proportion to the stele, the inner cortical layers being slightly affected by the suberisation of the endodermis. The primary stele of the main roots is pentarch, that of the smaller roots triarch, and of the lateral roots diarch. Secondary development of the stele is not accompanied by development of secondary cortex; the outer layers of the existing cortex become collenchyma. The root apex shows a normal stratified meristem; there is a large conical root cap (fig. 7).

Vegetative propagation and perennation is effected by

hypogeal stolons, which are developed very early on young plants, and arise in the axils of kataphylls near the base of the main stem. In late summer large specialised hypogeal buds are formed on these stolons at intervals of four internodes. One of the two axillary buds at a node increases in size, develops three or four strong roots, and becomes filled with starch reserves in the form of both simple and compound

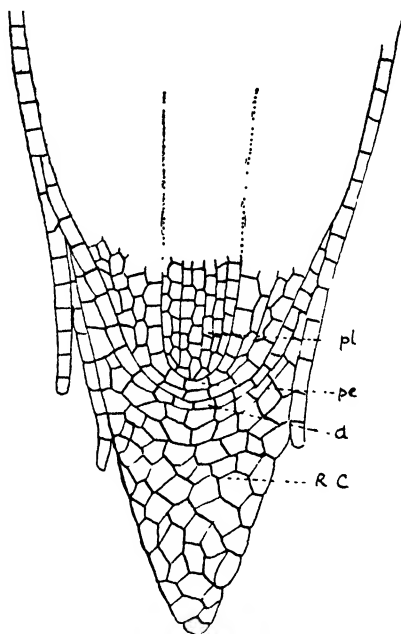


FIG. 7.—Median longitudinal section of the apex of the root ($\times 160$).

pl=plerome ; pe=periblom ; d=dermatogen ; RC=root cap.

grains. These are present throughout the cortex of the roots, in the cortical and medullary cells of the axis, and in the mesophyll of the kataphylls. Normally the outer bud remains dormant, but rarely both may develop in this way. When fully formed they are half to one inch long and pinkish in colour, due to anthocyanin in the subepidermal layers on the abaxial surface of the kataphylls.

In autumn the entire plant dies down, the stolons decay, leaving the buds free in the soil, where they remain dormant as the perennating organs of the plant.

Growth in spring begins by the development of lateral roots, which is followed by the elongation of the axis and the exposure of the apex to light. At this stage the buds contain a high concentration of anthocyanin. Under the influence of light there is a gradual transition from kataphylls to green assimilating leaves, and by early lateral branching near the ground-level the bushy character of the plant is again attained.

REFERENCES.

- (1) DECROCK, E. : Anatomie des Primulacées. Ann. Sci. Nat. Bot., sér. 8, xiii, 1901.
- (2) SOLEREDER, H. : Systematic Anatomy of the Dicotyledons, English trans., 1, 1908.
- (3) MAXIMOV, N. A : The Plant in Relation to Water. English trans , 1929.

NOTES ON SALT-MARSH PLANTS. II. *PLANTAGO MARITIMA*
LINN. By DAVID F. STEWART, B.Sc.

(Read 18th June 1931.)

Material was collected from six different stations :

A. The seaward side of a Salt-Marsh Community, where the plants are submerged daily.

B. The extreme landward side of the same community.

C. A " Fresh-Salt Marsh " where the water is intermittently fresh.

D and E were in the Cliff Community.

F. The seaward side of the Cliff Community.

The climatic conditions and nature of the substrate vary, the latter from pure clay with about 5 per cent. humus, to an equal mixture of clay and humus, to a mixture of sand, humus, and about 5 per cent. clay, to a mixture of sand, silt, and humus, to pure sand with about 5 per cent. humus.

The pH varies from 6.5 to 8.8.

In general, it was found that the more sheltered a plant is, the bigger are the dimensions of the vegetative organs, *e.g.* the lamina of the most sheltered plant (Station B) was five times longer and four times broader than that of the most exposed plant (Station F). The rootstock was 7.1 times longer and 1.3 times broader. But occasionally there are divergences, *e.g.* one plant was more sheltered than another, yet the lamina of this plant was only half as long as that of the other. This difference may be correlated with chemical soil differences, in which case it must be inferred that both edaphic and epidaphic factors are concerned in the moulding of the external configuration of both leaf and rootstock.

Other differences in the external morphology of plants from the various stations are :

1. Change in nature of the root system. In Stations A, B, and C the tap root is masked by the numerous adventitious roots. In the other three stations in the Cliff Community the converse is true.

2. The outline of the leaves may be linear or linear-oblongate.

3. The number of leaves per rootstock varies from five to eighteen.

4. The leaves may be oriented vertically or horizontally.

5. In each case the rootstock is multicipitate, but the number of branches varies from five to about one hundred.

The following external features are common to all leaves :—

1. A system of circular depressions, each containing one bicellular capitate hair, which may be a hydathode.

2. The stomata, more numerous on the upper than on the lower surface, are visible to the naked eye as minute white spots.

3. A system of unicellular or bicellular conical trichomes, which are covered by an epidermis continuous with that of the ordinary epidermal cell.

THE LEAF OF *PLANTAGO MARITIMA* WITH REFERENCE TO ZALENSKI'S HYPOTHESIS.

This hypothesis states that the higher the attachment of a leaf on a stem, the more numerous the stomata per unit area, and the stronger the relative development of venation; also that the rate of increase of venation density is greater in plants of exposed than in plants of more sheltered habitats.

The problem in this work is to ascertain whether the hypothesis holds good from base to apex of a single leaf, although it must be remembered that uniform areas are not being considered.

Leaves from Stations F, A, and C were investigated in addition to leaves from a plant which had been transferred to the Botanical Gardens, St. Andrews, about ten years ago. The laminae of these leaves measured respectively, 5, 13, 13, 13 cm. in length. In the first case (Station F) preparations were made at points 0.5, 1.5, and 3.5 cm. from the apex; in the next three cases at points 2.5, 6.5, 10.5 cm. from the apex.

In all twelve preparations a piece of upper epidermis was investigated for stomata, while the venation below that epidermis was considered. Care was taken that the venation, which is convergent striate reticulate, was examined between the two corresponding parallel mid ribs in each of the four leaves. Because of the succulence of the leaves, the veins are normally invisible to the naked eye. The method adopted to

display the venation was to allow the leaves to soften for a day or two in water, and then, after peeling off a small piece of upper epidermis, to scrape carefully away the mesophyll tissue from above downwards. By means of Camera Lucida drawings (fig. 1, *a*, *b*, *c*), the exact number of stomata per unit area could be counted and the comparative length of veins could be measured in cm. The latter result was verified by counting the number of meshes between the veins. It was found that the number of stomata and length of venation per unit area progressively increased from base to apex (Table I.).

TABLE I

Station	No. of Stomata from Base to Apex			Total	Length of Veins (in cm.) from Base to Apex			Total	No. of Meshes
Cliff	37	61	76	174	34	46	59	139	78
Garden	29	37	58	124	25	30	45	100	48
Salt Marsh	25 (Fig. 1 <i>a</i>)	35 (1 <i>b</i>)	39 (1 <i>c</i>)	99	19 (Fig. 1 <i>a</i>)	24 (1 <i>b</i>)	43 (1 <i>c</i>)	86	38
Fresh- Salt Marsh	18	27	38	83	13	29	45	87	40

Therefore, in each individual leaf Zalenski's hypothesis holds good, that is, the nearer the apex the greater the number of stomata per unit area and the stronger the relative development of venation. The following explanation has been offered. It has been proved that the intensity of transpiration of leaves developed in the sun is greater than those developed in the shade. In this case of a single leaf, the apex is developed later in the year, at a time when the atmosphere is less humid and the sun's rays are stronger. Therefore, the transpiration pull at the apex exceeds that at the base. Correlated with this difference in transpiration pull is the difference in the number of stomata and in venation density from base to apex.

The other part of the hypothesis, stating that the rate of

increase of venation density on ascending the stem was greater in plants of exposed than in those of more sheltered habitats, does not hold for a single leaf from base to apex.

The question arose: Is the hypothesis applicable to a single leaf in different habitats, or do leaves in a dry atmosphere

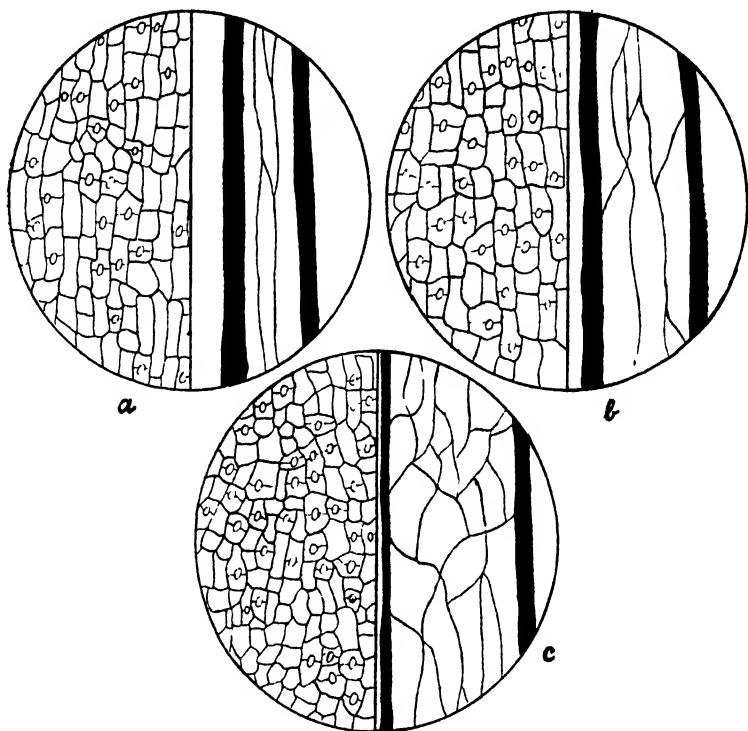


FIG. 1.—Number of stomata: *a*, 25; *b*, 35; *c*, 39 ($\times 50$). Length of veins: *a*, 19 cm.; *b*, 24 cm.; *c*, 43 cm. ($\times 20$).

possess more stomata and a denser venation than those in a more humid atmosphere? The stations in order of greatest humidity are: C, A, Garden, and F. According to Zаленский, the order of stations with foliage possessing the greatest number of stomata and densest venation should be reversed. Studying Table I. vertically, this order is strictly true for stomatal distribution. There is one divergence in venation. It may be taken, therefore, that the hypothesis holds for entire leaves in different stations as well as for different levels of the

same leaf. This conclusion is mainly based on stomatal distribution.

These results lend support to the view that the presence of sodium ions retards absorption. Although the exact contents were not ascertained, the Salt Marsh substrate must necessarily possess more sodium than that of the garden. In agreement with the view above, the number of stomata and venation density are less in leaves from the former plant.

Leaves from Stations A, C, and F were now studied under the heads enumerated below in relation to further results obtained by Zalenski, who states that, in comparison with the state of affairs in the lower leaves, the higher a leaf is inserted :

1. The greater the development of mechanical tissue.
2. The more typical the development of palisade tissue.
3. The less typical the development of spongy mesophyll.
4. The weaker the development of the system of intercellular spaces.
5. The smaller the dimensions of all kinds of mesophyll cells.
6. The thicker the outer wall of both upper and lower epidermal cells.
7. The smaller the dimensions of both upper and lower epidermal cells.
8. The less sinuous the lateral walls of the epidermal cells.

Results in this work dealing with a single leaf:

1. *Mechanical Tissue.* This is collenchyma and present in three areas of the leaf : at the two margins, and in the middle, just above the lower epidermis. The total number of collenchymatous cells decreased from base to apex.

2. *Development of Palisade and Mesophyll Tissue.*—There is a progressive increase of palisade tissue from base to apex and a corresponding decrease in spongy mesophyll.

3. *Intercellular Spaces.*—These become progressively fewer and smaller from base to apex, both in spongy mesophyll and palisade.

4. *Size of Mesophyll Cells.*—In Stations F and A these become progressively smaller from base to apex, while in Station C they are biggest at the middle, smallest at the apex, and intermediate at the base.

5. *Thickness of Outer Epidermal Wall.*—There is a slight

tendency to increase in thickness from base to apex, especially in a leaf from Station F.

6. *Sinuosity of Lateral Walls of Epidermal Cells*.—Sinuosity increases from base to apex in leaves from Stations C and A. The change is scarcely distinguishable in Station F.

7. *Thickness of Cuticle*.—There is no appreciable difference from level to level or from station to station.

Histology of Leaf (additional features common to all the leaves).—The stomata have subsidiary guard cells. The outer wall of these cells, as well as of the guard cells, is cutinised. There are no water stomata. The principal meristeles run parallel. They are normal, but are supported above and below by stereom crescents. The whole is enclosed in an endodermal sheath containing starch grains. The whole of the radial wall of these endodermal cells is cutinised.

Histology of the Rootstock (Station A).—Both periderm and secondary stelar thickening begin extremely early. The phellogen originates several cells deep in the cortex, while the stelar cambium lays down radial rows of secondary parenchyma.

Histology of Root.—As in the rootstock, both kinds of secondary thickening begin very early. Even the fine fibrous roots collected at a depth of about 3 feet did not reveal the primary structure. Sections of these showed a diarch stele with medullation setting in. The thickness is mainly due to the abnormal amount of secondary cortex. Instead of secondary xylem, the stelar cambium lays down radial rows of parenchyma.

Propagating experiments with leaves of *Plantago maritima* (at 30° C.):

A. Lying horizontally, with basal cm. covered by soil.

1. Entire.
2. Entire, but slashed transversely.
3. Entire, but slashed longitudinally.
4. Base removed.
5. Base plus basal third of lamina removed.
6. Apical and basal third of lamina removed.

B. Inserted vertically.

1. Entire.
2. Base removed.
3. Base plus basal third removed.

Within a month all had wilted and died except one—one which had had its base removed and was lying horizontally (A 4). This one had developed two branched roots from the cut surface. Even this one positive result proves that it may be possible to propagate *Plantago maritima* vegetatively by means of leaves, especially as these experiments were carried out at the end of the season, when the leaves were waning in vitality.

Further propagating experiments with

1. Rootstocks alone.

2. Rootstocks with leaves still attached.

A. Inserted vertically.

1. Basal cm. removed—upper four cm., bearing leaves, inserted in soil.

2. Basal and apical cm. removed. The apical end placed in soil.

3. As A 2, but basal end in soil.

B. Lying horizontally.

1. Basal and apical ends removed.

All developed roots from the basal cut surface. Those which had no leaves originally developed them from the apical cut surface. They grew strongly for a time but eventually, after thirty-four days, all had died. This was probably due to frequent handling for measuring purposes and also to the unfavourable season (28th October to 1st December).

The writer wishes to express his indebtedness for facilities and assistance afforded him at the Botanical Department, St. Andrews.

REFERENCES.

- (1) MAXIMOV, N. A.: *Plant in Relation to Water*, English trans. by R. H. YAPP, 1929.
- (2) SOLEREDER, H.: *Systematic Anatomy of Dicotyledons*, English trans. by BOODLE and FRITSCH, 2 vols., 1908.

NOTES ON SALT-MARSH PLANTS. III. TRIGLOCHIN
MARITIMUM LINN. By JAMES PARK, B.Sc.

(Read 18th June 1931.)

Hill has given an account of the morphology and anatomy of the vegetative organs and inflorescence axis, together with the development of the flower, anatomy of the embryo sac, and the embryogeny (1).

A comparative account of the leaves of eleven different species of *Triglochin* is submitted by Arber (2).

The *Triglochin maritimum* used in this investigation was collected from several places in the salt marsh at the Eden estuary; the different positions have varied soil constituents, water-content, and pH concentration. Examination in the field revealed no differences in external morphology in plants from different stations.

THE LEAF IN RELATION TO ZALENSKI'S HYPOTHESIS.

Zalenski's hypothesis is outlined in Maximov's "Plant in Relation to Water" (3), and has been alluded to in papers I. and II. on Salt-Marsh Plants (*supra*).

Points corroborated in the work are as follows:—

In leaves of *Triglochin* from base to tip of the leaf, there is

- (1) an increase in the number of stomata per unit area of leaf surface, the numbers being approximately equal on both sides of the leaf.
- (2) From base to tip of the leaf there is a decrease in the size of the stomatal apparatus of the epidermal cells, while the longitudinal walls become less regular towards the leaf tip.
- (3) The average size of all the elements decreases from base to tip of the leaf, the palisade mesophyll showing the least change.
- (4) The proportion of palisade to spongy mesophyll increases from base to tip of the leaf.
- (5) The outer wall of the epidermis, which is of cellulose, is very markedly thicker at the tip than at the base.

The actual variation in thickness of the cuticle is negligible.

- (6) The sheaths of thickening are less prominent at the tip of the leaf.
- (7) The intercellular spaces are much more marked towards the base of the leaf.

A comparative study of consecutive parts of a leaf with regard to venation is not very satisfactory, due to the shape of the leaf. However, the number of strands passing unit length of circumference and passing unit area of cross-section of the leaf were measured, and it was found that in both cases the number increased from the base to the tip of the leaf. This may be correlated with the stomatal distribution.

In conclusion, it is considered that though some of the facts mentioned might be explained as due to condensation towards the leaf tip, Zalenski's hypothesis may be applicable to single leaves of the *Triglochin* type.

GERMINATION OF SEED AND GROWTH OF SEEDLING.

The seeds are enclosed one per carpel and are dispersed inside the latter in a manner similar to those of *Geraniaceae*, the style remaining probably as a hook for dispersal.

The seed is anatropous, with a membranous seed-coat, exendospermic, embryo straight, average length 1.5 mm., and average breadth .5 mm. The embryo is differentiated to primary root, hypocotyl, and cotyledon, while another leaf may be differentiated in the plumule.

Seeds planted in October did not show till the middle of January, but those planted after that time germinated in about 1½ days after sowing. Germination is epigeal, the seed-coat and carpel being carried above ground covering the cotyledon tip. The seed-coat is often carried out on the primary root when seedlings are grown on wet filter paper. The percentage germination was 64 per cent.

There is a well-developed piliferous layer in three days, the second leaf appears in about nine days, but the root grows very slowly. In a month-old seedling four leaves are generally developed, including the cotyledon, which is about 3 cm. long.

The distichous arrangement of the leaves is readily seen. A ligule is present in the first plumular leaf but is not

differentiated in the cotyledon. One or two adventitious roots have developed laterally from the base of the hypocotyl, the first soon reaching the length of the primary root.

ANATOMY OF TWO-WEEKS-OLD SEEDLING.

In a two-weeks-old seedling two leaves are easily visible, the cotyledon being about 18 mm. long. The distribution of the vascular bundles about the third node is shown in fig. 1 (i).

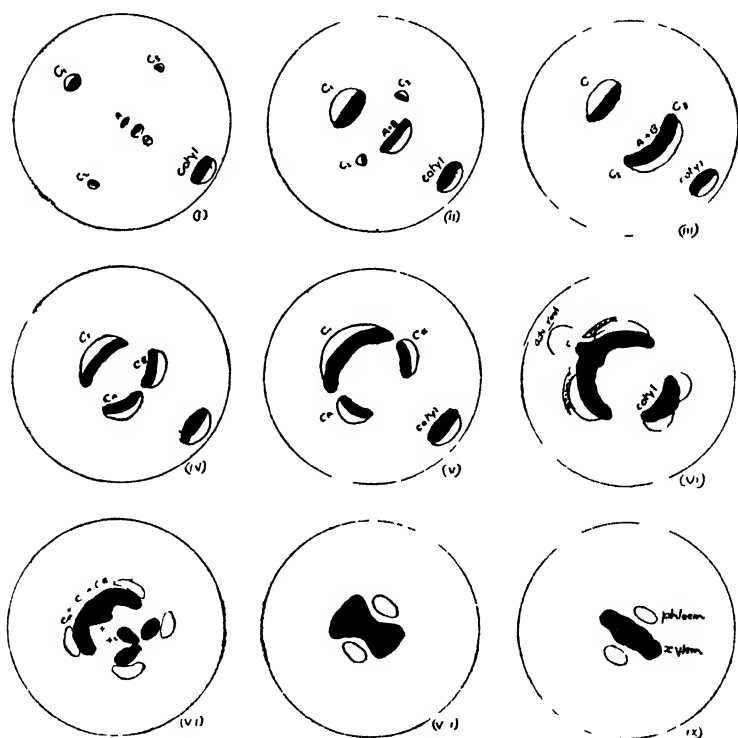


FIG. 1—*Triglochin maritimum*. Diagrammatic transverse sections of 2-weeks-old seedling, showing stages in transition from plumule to root.

A and B represent the rudiments of the leaf traces of the third and second leaves respectively, C_1 , C_2 , C_3 those of the first leaf, and "Cotyl" the cotyledonary trace. Thereafter the course of the bundles can be followed from the diagrams. A and B fuse (fig. 1, ii) C_2 and C_3 , the lateral strands of the

first leaf trace join the ends of the fusion system A and B (fig. 1, iii). The bundle so formed breaks to two parts (fig. 1, iv). These parts C_A and C_B become attached to the ends of the main strand of the first leaf trace C_1 , forming a semicircle (fig. 1, vi). From C_1 the stele of the first adventitious root is given off while the cotyledonary trace enters opposite (fig. 1, vi). The phloem up to this point has been more or less in its usual position, external to the xylem, but it is very scanty. The cotyledonary phloem breaks to two patches, as also does that of the patch $C_1+C_A+C_B$ (fig. 1, vii). The cotyledonary xylem strand breaks up too, protrusions x_1+x_2 are produced from both xylem patches, which ultimately join the two patches to form a diarch stele with lateral protrusions (fig. 1, viii). About the same place the lacunar cortex of the normal root becomes evident and the section is reduced in diameter. A normal diarch stele is produced (fig. 1, ix), the xylem being finally reduced to two patches of protoxylem, joined by thin-walled tissue.

The distance between sections represented by figs. 1 (i) and 1 (vi), was .35 mm., that between 1 (vi) and 1 (ix) about .2 mm.

ANATOMY OF FOUR-WEEKS-OLD SEEDLING.

A four-weeks-old seedling shows three leaves besides the cotyledon, the latter being about 3 cm. long. One adventitious root is generally developed, being as long as the primary root. The hypocotylary region is still very small, less than 5 mm.

Fig. 2 (i-x) shows diagrammatically the positions of the leaf traces. Six leaves were already differentiated in the plumule.

Fig. 2 (i) shows a section about the fifth node, the leaf traces of the first to fifth leaves being lettered E-A respectively. The side strands of the fourth leaf, B_2 and B_3 , fuse with A, the main strand of the fifth leaf trace, which then fuses with the fourth main strand, B. The mass of xylem so formed breaks to two parts, b_1 and b_2 (fig. 2, ii), which fuse with C_2 and C_3 , the side bundles of the third leaf trace. The second leaf trace, D_1, D_2, D_3 , now enters (fig. 2 iii) the side strands, D_2 and D_3 , fusing with main strand, C_1 , of the third leaf, while D_1 fuses with the two side bundles represented by b_1+C_2 ,

$b_2 + C_3$ (fig. 2, iv). The patch formed from the third leaf trace now breaks to two parts, d_1 and d_2 , which join to the ends of the main strand, E, of the first leaf trace (fig. 2, vi). The side bundles, E_2 and E_3 , join near the ends of d_1 and d_2 (fig. 2, vi). The xylem patches are, however, much broken up now, so the junction of the side strands, E_2 and E_3 , of the

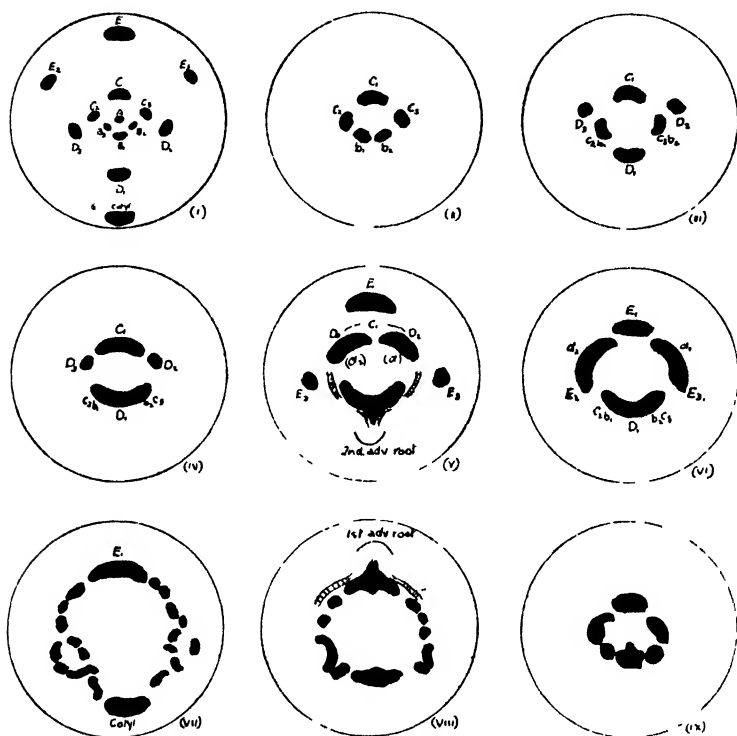


FIG. 2.—*Triglochin maritimum*. Diagrammatic transverse sections of 4-weeks-old seedling, showing leaf-trace system, origin of adventitious roots, and beginning of transition period.

first leaf is not definite (fig. 2, vii). The stele of the second adventitious root is given off from D_1 , while E_1 enters opposite (fig. 2, viii). After the position represented in fig. 2 (vi) is reached, there is a period during which the relative position of the xylem and phloem varies much, chiefly due to the formation (fig. 2 (vii)) of what are apparently rudimentary concentric bundles as are found in the adult rhizome. However, the xylem finally becomes approximately arranged in

a circle before the stele of the first adventitious root is given off, and before the joining of the cotyledonary trace opposite (fig. 2, viii). The stele becomes much condensed now, the xylem becoming medullated in various ways and the phloem almost disappearing, till finally an appearance is assumed approximating to that of the two-weeks-old seedling as before (fig. 1, viii). The stele looks like a tetarch stele, but four patches of phloem were not traced. A normal diarch stele is formed by the withdrawal of the protrusions.

It is remarked from the above description and a comparison of fig. 2 (i and iv, iii and v), that the leaf-trace system is symmetrical and that the roots, in the seedling at least, arise opposite the entry of a leaf trace.

The origin of the bundle sheaths, which are such a marked feature of adult leaves, is seen to be endodermal, but they were not apparent in seedlings till about a month old.

Seedlings of intermediate ages between these described were examined and were found to conform to those. Though the medullation in the transition region is by no means constant, the final result is a diarch root stele with protrusions as described.

The writer wishes to express his indebtedness for the facilities given him for carrying out the work in the laboratory at St. Andrews University.

REFERENCES.

- (1) HILL, T. G.: *Ann. Bot.*, xiv, 1900, p. 83.
- (2) ARBER, A.: *Bot. Gaz.*, xxxvii, 1924, p. 50.
- (3) MAXIMOV, N. A.: *Plant in Relation to Water*, 1929, p. 328 *et seq.*

THE SCOTTISH ALPINE BOTANICAL CLUB EXCURSION, 1930.
By ROBERT MOYES ADAM. (With Pls. XX-XXI.)

(Read 15th October 1930.)

The scene of the 1930 excursion was fixed for Achnashellach in West Ross-shire, the Club having been invited to be the guests of Mr. and Mrs. Sandeman at their lodge. A few days, however, before the date of the meeting word was received by the President that serious illness had overtaken Mrs. Sandeman, and consequently all arrangements were abandoned.

Thereafter, in consultation with the President and Secretary, an alternative rendezvous was chosen for the Club meet at Loch Laggan Hotel, and in which place subsequently, on 16th July, a representative gathering took up residence. This region, which was new to the Club, had much to commend it. The published records of the botany are few, and within accessible distance lie some big tracts of elevated land with attractive corries.

Loch Laggan must be reached by road, and the Club made this approach by motor-car from Kingussie—a pleasant route, first through Newtonmore and thence by skirting the Monadhliath Hills, where birch woods fringe the lower slopes—past Cluny Castle, with its Jacobite memories, to Laggan village. From Laggan the route bears south-west and crosses the infant Spey to enter Strathmashie, and finally reaches the valley of the Pattock, a short river which rises on the north-east side of Ben Alder, and performs a semicircular course to escape from the Spey watershed and so drain south-west and enter Loch Laggan.

The latter part of the route introduced members to the vast afforestation schemes begun some sixty years ago by the late Sir John Ramsden, Bart., and continued now by his son, the present baronet. These larch and pine plantations, with other conifers, present an instructive example of foresight and enthusiasm in the art of creating forest. Fifty years ago most of this landscape was treeless, while to-day there are many square miles of growing timber. The area



Coire Coille na Fioise with the lochan that lies at the base of the cliffs, Loch Lagan in the distance

owned by the Ramsdens extends to 10 miles in every direction from their residence at Ardverikie, and should their schemes mature all plantable land will be afforested.

This region possesses more than ordinary attractiveness, and it is of interest to record that the late Queen Victoria sought to establish her highland home at Ardverikie before her choice of Deeside.

After installing themselves in the hotel, the Club party spent the evening making contact with the factor of Ardverikie, a genial fellow by name Mr. Thomas Logan. From him a welcome was extended to the Club in the name of Sir John Ramsden, who further let it be known that the Club were at liberty to exploit in the fullest measure all the botanical interests of his estate—a privilege the Club appreciated highly and which was acknowledged on behalf of the Club by the President.

In a field near the factor's house at Gallovie some fine plants of *Leucorchis alba* were seen in full flower, and in a pine plantation some remarkable white foxgloves, a few of which exhibited *Peloria*.

The great day of the meet was on 17th July, plans having been made to tackle one or more of the great corries facing east on Creag Meaghaidh—the big green hill that dominates the horizon west of Loch Laggan, now part of Aberarder Deer Forest, but formerly used as a sheep run.

For the outward journey the Club sought assistance from the hotel car, and by its means were conveyed to Moy, six miles distant and at the south-western extremity of Loch Laggan. Moy in the old days was a stage house for posting traffic between Strathspey and Fort William—it is now occupied by an Ardverikie stalker.

The weather prospects on setting out were distinctly gloomy, and rain commenced after dismissing the car, and continued intermittently throughout the day. A steady pull uphill above Moy brought members over a moor dominated by *Scirpus caespitosus*, and in the bogs *Drosera anglica* was plentiful. Beyond the 1000-foot contour the vegetation changed, and in place of heath a wilderness of boulders strewn the hillside, which made the ascent tedious. Around 1800 feet more heath appeared, and among it *Cornus suecica*—numerous plants, but flowerless. On a small cliff the first

rock alpenes appeared in *Saxifraga stellaris* and *Salix Lapponum*.

Thereafter the ascent became steeper and plant life less luxuriant. The slope became carpeted with stunted *Calluna*, *Empetrum*, and *Vaccinium Myrtillus*, and, mixed in, plants of *Loiseleuria procumbens*, prostrate and hugging the windswept surface. At 2000 feet rocky outcrops indicated the entrance to Coire Coille na Froise, and the first to be explored. Mist and low clouds hid the summit and threatened to drop lower, but these conditions did not prevent a thorough examination of several gullies at this point. Rewards were few, as the rocks were found to be dry and with an angle of slope unfavourable to plants.

A mile distant the innermost recess of the corry could be seen between the clouds with an apparent series of gullies descending sharply to a tiny lochan at their base. By traversing along the south side of the corry and keeping just below the cloud level, which was about 2600 feet, rocks were ultimately reached with quite favourable aspects and holding a wealth of vegetation. Over many parts water flowed freely—some apparently from large snow-patches on the higher levels in the corry. In one gully over 200 feet of snow lay to a depth of 15 feet. At one part the underside had melted to form an arch a few inches above the scree—where *Caltha palustris* had quite a show of flowers, yet a few feet distant, and where no snow lay, Marigolds were just in leaf. Over some ledges quantities of *Saussurea alpina* were just in bud, *Trollius europaeus* in flower, and on ledges with abundant soil a riot of plants, among which *Rubus saxatilis* and *Luzula sylvatica* seemed to dominate. Some *Silene acaulis* was seen in flower, but this plant was not plentiful, and where the splashing of the dripping rocks kept the soil wet some splendid flowering groups rose of *Saxifraga hypnoides*. On the scree slopes, where fresh water flushes made their way, clumps of *Carex* thrived, and conspicuous among their number the dark heads of *Carex pulla*. In similar situations the alpine grasses *Alopecurus alpinus* and *Phleum alpinum* threw up many tall heads. At one place in the corry progress was barred until a descent to the lochan enabled the party to escape from a difficult cliff. The ascent on the far side, however, compensated and gave access to some attractive terraces at the head

of the corry. Over this ground great plants of *Cochlearia alpina* appeared in full bloom, and on the side of the chief stream which fed the lochan, and where it fell over precipitous rocks, many plant discoveries were made.

About this time the clouds lifted and encouraged the party to ascend to the summit of the corry, which, being accomplished, brought them towards the north shoulder, where the elevation reached 3400 feet. From this vantage point the corry was viewed—a scene wild and desolate—a wide amphitheatre of rocks and scree in the foreground, while far beneath the tiny lochan looking dark and still. Beyond and to the east the big hills about Ben Alder appeared dimly in the gloom. Westwards the eye roamed over a wide plateau—the summit of Creag Mheaghaidh, the top so flat that an aeroplane could land with safety, and a slight rise to the cairn which denoted the 3700-foot point. The surface soil was peaty and showed little signs of erosion in spite of the elevation, and the whole carried a splendid cover of *Nardus* grassland.

From the view-point a move for half a mile in a north-westerly direction brought the party to the brim of Coir Ardoir Creag Meggie's grandest corry—a scene of awesome grandeur with perhaps few rivals of its kind in the Scottish Highlands. The edge of the corry reaches the 3600-foot elevation, and from it descend a series of precipices, which vary in height and steepness. Two great buttresses in the centre drop down sheer for 1200 feet. These are known as the "Posts" of Coir Ardoir, and are to ordinary hill-folk unscalable. A notch-shaped depression towards the north-west corner of the corry is the "Window of Coir Ardoir," and is a well-known feature in the mountain outline when viewed from the east. Through this gap the pass connecting Laggan to Glen Roy reaches an elevation of 2800 feet, and was used by Prince Charles Edward during his flight after Culloden, and when on his way to Badenoch in 1746.

An approaching rainstorm cut short botanizing operations on the summit, and the party made a rapid descent by the side of a long snow slope, and ultimately reached the level of the lochan that nestles at the base of the cliffs. At this point the deer forest track was struck, and by its aid the final stage of the day's march was begun. Some very intimate sights of Red Deer grazing the slopes in the lower parts of the glen

enlivened the three miles of rough walking, and ultimately brought the party within sight of the road at Aberarder Farm.

The final stage was completed by car, and after a 12-hour day in the field the hotel was reached, with the opinion formed that in spite of the weather a profitable day had been spent and an important record added to the Club annals of lesser-known territory.

The 18th of July brought rainy weather, and consequently a light programme was carried through.

The forenoon was spent in the vicinity of the hotel, and with a walk down Loch Laggan towards Aberarder. Where the River Pattock entered the loch the abnormally low state of the water was evident from the large sandbanks that were exposed, rendering the loch at this end fordable.

After lunch the woods of Ardverikie were visited, and this was done by entering the policies by the main gateway and iron bridge over the Pattock. From the bridge the party kept to the main avenue—a beautiful walk, on both sides of which common and rare conifers were observed in all stages of growth. The avenue skirts the shore for nearly three miles, and throughout its length offers particularly fine glimpses of Loch Laggan, the best view-points having been improved by the removal of trees which at one time must have interfered with the prospect. On the margin of the avenue several groups of *Pyrola minor* were seen in fine flower, and in the forest region close by Ardverikie Castle Rhododendrons formed quite a jungle of growth.

Continuous rain made the afternoon unpleasant, and after reaching Ardverikie the route was reversed and a speedy return made to the hotel.

On the 19th the Club woke to good weather and their departure, but as this hour was not until afternoon an energetic member set off to explore the slopes of Carn Liath and the slopes of Coir Ardoir. He returned in time to join the departing company, having collected quantities of *Rubus chamaemorus* in excellent fruit on the high slopes of Carn Liath at 2000 feet.

The Club meet drew to a close with the arrival of the mail coach, thereafter conveyance to Kingussie to entrain, and their separate destinations.

The following plants were noted : *Thalictrum alpinum* Linn.,



Ardvenkie, Loch Lagganside, showing afforested lands and the summits of Benn Shios and Creag Peathraich on the horizon



The summit of Creag Meaghaidh, with the precipices of Cnoc Ard Dhoir.
The 'window' is the notch shaped depression on the skyline, and the
'posts' are the rock buttresses in the centre

Caltha palustris Linn., *Trollius europaeus* Linn., *Cochlearia alpina* Wats., *Silene acaulis* Linn., *Cerastium alpinum* Linn., *Prunus Padus* Linn., *Rubus saxatilis* Linn., *R. Chamaemorus* Linn., *Geum rivale* Linn., *Potentilla Sibbaldi* Hall. fil., *Alchemilla alpina* Linn., *Saxifraga aizoides* Linn., *Sedum roseum* Scop., *Drosera anglica* Huds., *Epilobium anagallidifolium* Lam., *Angelica sylvestris* Linn., *Cornus suecica* Linn., *Galium boreale* Linn., *G. saxatile* Linn., *Gnaphalium supinum* Linn., *Saussurea alpina* DC., *Vaccinium uliginosum* Linn., *Azalea procumbens* Linn., *Pyrola minor* Linn., *Gentiana campestris* Linn., *Veronica humifusa* Dickson, *V. alpina* Linn., *Salix lapponum* Linn., *S. herbacea* Linn., *Gymnadenia conopsea* Br., *Leucorchis albida* Mey., *Juncus trifidus* Linn., *J. castaneus* Sm., *J. biglumis* Linn., *Triglochin palustre* Linn., *Carex canescens* Lightf., *C. leporina* Linn., *C. rigida* Good., *C. pallescens* Linn., *C. binervis* Sm., *C. flava* Linn., *C. saxatilis* Linn., *Alopecurus alpinus* Sm., *Phleum alpinum* Linn., *Cryptogramme crispa* Br., *Cystopteris fragilis* Bernh., *Polystichum Lonchitis* Roth, *Phegopteris Dryopteris* Fée, *P. polypodioides* Fée, and *Lycopodium alpinum* Linn.

NOTES ON COMMON DISEASES SOMETIMES SEED-BORNE.

By N. L. ALCOCK, F.L.S.

(Read 15th October 1931.)

The list of seed-borne diseases here put forward is not definitive, and only given tentatively. The arrangement of plants is that adopted by the Ministry of Agriculture in Miscellaneous Publications, No. 70, "Fungus and Allied Diseases of Crops."

It is hoped that further work will be done on these diseases at the Royal Botanic Garden, and photographs of the stages of the fungi on the seed obtained.

ROOTS.

SWEDES.

Dry Rot (*Phoma Lingam* (Tode) Desm.).

Downy Mildew (*Peronospora parasitica* (Pers.) Tul.).

Powdery Mildew (*Erysiphe Polygoni* DC.).

TURNIPS.

Dry Rot (*Phoma Lingam* (Tode) Desm.).

Swede and Turnip seed that carry this disease appear discoloured, wrinkled, and dull, possibly showing a little mycelium or threads. The small pycnidia (black minute bodies) are very seldom seen, but on germinating the seed in sterile conditions they may appear plentifully after about three weeks on the young stem and first two leaves.

Downy Mildew (*Peronospora parasitica* (Pers.) Tul.).

Downy Mildew does not usually appear on the seed, but in a badly affected sample the oospores may sometimes be found (with a microscope) on washing the seed and on any pieces of the plant that have escaped cleaning.

White Blister (*Cystopus candidus* (Pers.) de Bary).

This may rarely be seen as minute white spots on the seed, but more often on small particles of plant tissue. Rare.

Black Rot (*Pseudomonas campestris* (Pamm.) E. F. Smith).

MANGOLDS.

Rust (*Uromyces Betae* (Pers.) Tul.).

Black Leg (*Phoma Betae* (Oud.) Frank).

Rhizoctonia sp.

SUGAR BEET.

Rust (*Uromyces Betae* (Pers.) Tul.).

Rust on the compound seed of Beet or Mangold usually appears as yellow spots, these are sori containing uredospores. The seed is lighter in weight but darker in colour than usual. The spots need a lens to be seen, and may be hidden in the folds of the compound seed.

Black Leg (*Phoma Betae* (Oud.) Frank).

Black Leg appears as pycnidia (*i.e.* small black bodies full of spores) on the compound seed case, to be seen with a lens. It may wipe out seedlings.

Rhizoctonia sp.

This fungus, which is very common among Beet and Mangolds and various seeds, occurs as brown threads only. It acts as a damping-off fungus and may be troublesome. If plentiful, it can be seen with a lens and the seeds will be dark and dirty looking.

Mildew (*Peronospora Schachtii* Fuckel).

Leach found mycelium and oospores on the seed-coat.

PULSE.

DWARF BEANS.

Pod Canker (*Colletotrichum Lindemuthianum* (Sacc. et Magn.) Bri. et Cav.).

RUNNER BEANS.

Pod Canker (*Colletotrichum Lindemuthianum* (Sacc. et Magn.) Bri. et Cav.).

Pod Canker appears on the seed of Dwarf and Runner Beans as a depressed area, light brown usually with a purple rim. If the bean is soaked and examined, some mycelium (fungus threads) will be found under the seed coat.

BROAD BEANS.

Rust (*Uromyces Fabae* (Pers.) de Bary).

Rust on Broad Beans is more likely to be carried on little pieces of pod or stem, appearing as yellow-brown spots.

Chocolate Spot (*Bacillus Lathyr*i Manns et Taubenh.).

This bacterial disease has been found on Beans from a diseased crop and shows as a dark chocolate-brown spot. It is carried by *Bruchus rufomaculans*, the Bean Beetle. Bored seed should be avoided.

FIELD AND GARDEN PEAS.

Powdery Mildew (*Erysiphe Polygoni* DC.).

Downy Mildew (*Peronospora Viciae* (Berk.) de Bary).

Downy Mildew of Peas sometimes attacks the pods very severely. Wrinkled, discoloured spots occur on the seeds, and sometimes oospores or resting spores can be found (microscope) in the seed coats.

Spot (*Ascochyta Pisi* Lib.).

This is carried as small pycnidia, showing as brown, not black, minute bodies on the pod. When the disease is severe, the infection goes through the pod to the seed.

Stripe (*Bacillus Lathyr*i Manns et Taubenh.).

This causes a discoloured spot in the centre of the seed that can be seen if the seed be cut.

FORAGE CROPS.

CLOVER.

Rust (*Uromyces Trifolii* (Hedw. f.) Lév.).

Black Blotch (*Dothudella Trifolii* (Pers.) Bayl.-Elliot et Stans.).

Leaf Spot (*Pseudopeziza Trifolii* (Biv.-Bern.) Fuck.).

Sclerotinia Trifoliorum var. *minor* (?).

This small sclerotinial disease borne by Clover seed may not occur on seed grown in this country, but has been found on seed from abroad, and the fungus grown out in the Laboratory. The other three Clover diseases require further research.

Scorch (*Kabatiella caulivorum* (Kirchn.) Karak.).

This has been found to be carried on the seed.

VEGETABLES.

ARTICHOKE (Jerusalem).

Sclerotinia Sclerotiorum (Lib.) de Bary.

This fungus has been grown in culture from small sclerotia on the seed.

BEEF.

Rust (*Uromyces Betae* (Pers.) Tul.).

See note on Mangold and Sugar Beet.

BRASSICAE.

Stem Rot (*Phoma Lingam* (Tode) Desm.).

Downy Mildew (*Peronospora parasitica* (Pers.) Tul.).

Black Rot (*Pseudomonas campestris* (Pamm.) E. F. Smith).

CARROT.

Sclerotinia Sclerotiorum (Lib.) de Bary.

Rhizoctonia sp.

CELERY.

Leaf Spot (*Septoria Apii* Chester).

LEEK.

Rust (*Puccinia Porri* (Sow.) Winter).

Smut (*Urocystis Cepulae* Frost).

LETTUCE.

Ring Spot (*Marssonina panattoniana* Berl.) (doubtful).

ONIONS AND SHALLOTS.

Mildew (*Peronospora Schleideni* Ung.).

Rust (*Puccinia Porri* (Sow.) Winter).

Macrosporium parasiticum Thum.

In examining samples of Leek and Onion seed, I have not found the spores of Smut, but oospores of Mildew, and spores of *Macrosporium* are often present.

PARSLEY.

Leaf Spot (*Septoria Petroselinii* Desm.).

SALSIFY.

White Rust (*Cystopus cubicus* (Strauss) de Bary).

Smut (*Ustilago Tragopogonis pratensis* (Pers.) Rouss.) (rare).

TOMATO.

Mosaic (Virus disease).

Experiments in recent years at Cheshunt have shown that this is seed-borne.

Canker or Stem Rot (*Diplodina Lycopersici* (Cooke) Hollós).

Buck-eye Rot (*Phytophthora parasitica* Dastur).

This is probably seed-borne from badly infected fruits and may be one of the causes of damping-off.

FLAX.

FLAX.

Rust (*Melampsora Lini* (Pers.) Desm.).

Seedling Blight (*Colletotrichum Lini* (Westerd.) Toch.).

FLOWERS.

ANTIRRHINUM.

Stem Rot (*Phyllosticta Antirrhini* (Syd.)).

DAHLIA.

Sclerotinia Sclerotiorum (Lib.) de Bary.

In this case the fungus makes sclerotia, or black lumps, on the seeds similar to those formed on the Salsify seed.

MECONOPSIS sp.

Downy Mildew (*Peronospora arborescens* (Berk.) de Bary).

SWEET PEAS.

Streak (*Bacillus Lathyr* Manns et Taubenh.).

REFERENCES.

- ALCOCK, N. L. : Clover Seed. Comptes rendus de l'Association Internationale d'Essais de Semence, No. 6 (Copenhagen, 1928).
 BROOKS, F. T. : Plant Diseases (1928), 63.
 BUTLER, E. J. : Fungi and Disease in Plants (1918), 109.
 COOK, H. T. : *Peronospora Schleideni* on Onions. Phytopath., xx (1930), 139.
 COONS, G. H., and STEWART, DEWEY : Sugar Beet Seedling Diseases. Phytopath., xvii (1927), 259.
 CUNNINGHAM, G. H. : Swedes Dry Rot. New Zealand Department Agric. Bull., No. 133 (1927).
 DOYER, L. C. : Untersuchungen über den Gesundheitszustand des Saatguts. Comptes rendus de l'Association Internationale d'Essais de Semences, Nos. 13-14 (Copenhagen, 1930).

- GARNER, F. H., and SANDERS, H. G. : Sugar Beet. Min. of Agric. Journ., xxxviii (1931), 8.
- GENTNER, G. : Die Prüfung des Saatgutes auf Gesundheit und Frische. Landwirtschaftl. Jahrb. f. Bayern, xviii (1928).
- HENDERSON, M. P. : Cabbage Black Leg. Phytopath., viii (1918), 379.
- LEACH, L. D. : *Peronospora Schachtii* on Beets. Unpublished, see Jour. Sci. Iowa State Coll., v (1931), 185-188.
- LINFORD, M. B., and SPRAGUE, R. : *Ascochyta* sp. on the Pea. Phytopath., xvii (1927), 381.
- ORTON, C. R. : Seeds as Carriers of Disease. Journ. New York Bot. Gard., xxvii (1926), 54.
- PETHYBRIDGE, G. H., and LAFFERTY, H. A. : Flax. Sci. Proc. Roy. Dub. Soc., xv (1918), 359.
- SAMPSON, K. : Clover Anthracnose. Trans. Brit. Myc. Soc., xiii (1928), 103.
- WAKEFIELD, E. : *Phyllosticta Antirrhini* on Antirrhinum. Gard. Chron., lxxvi (1924), 150.
- WALKER, J. C., and TISDALE, W. B. : Cabbage Black Rot. Phytopath., x (1920), 175.

LIST OF FUNGOUS DISEASES RECEIVED BY THE PATHOLOGICAL
DEPARTMENT OF THE DEPARTMENT OF AGRICULTURE
FOR SCOTLAND. By N. L. ALCOCK, F.L.S., AND C. E.
FOISTER, B.A., Ph.D.

(Read 15th October 1931.)

The list now presented is that of diseases on plants that have been received since 1924 at the Plant Pathology Laboratory of the Department of Agriculture for Scotland, stationed at the Royal Botanic Garden, Edinburgh.

In the earlier years the plants sent in for diagnosis were not numerous, but the variety and number of diseases received have steadily increased in recent years as interest grew.

This is not in any way a complete survey, but shows briefly the advisory work of this Laboratory. It also suggests what might be done in the future, with more time and greater opportunities, in the compilation of a complete survey of plant diseases in Scotland.

The localities are not exclusive ; they are places whence the diseases were received. Many of the diseases are widespread.

The scientific names are arranged according to the list of the British Mycological Society, published in their Transactions, xiv (1929), 140-177. The economic crop plants are arranged as in the Ministry of Agriculture and Fisheries Miscellaneous Publications, 70, "Fungus and Allied Diseases of Crops, 1925-1927."

In the question of critical determination thanks are due to Dr. Malcolm Wilson, whose great assistance is hereby gratefully acknowledged.

FRUIT.

APPLE.

	Locality
Scab (<i>Venturia inaequalis</i> Aderh.)	General
Mildew (<i>Podosphaera leucotricha</i> (Ell. et Everh.) Salm.)	do.
Canker (<i>Nectria galligena</i> Bres.)	do.
Coral Spot (<i>Nectria cinnabarina</i> (Tode) Fr.). (Acting as a Canker)	East Coast
Rough Scab (<i>Coniothecium chomatosporum</i> Corda). (Fruit cracking)	Lothians
Silver Leaf (<i>Stereum purpureum</i> Pers.). Distributed, but not common	

	<i>Locality</i>
Brown Rot (<i>Sclerotinia fructigena</i> Schroet.)	General
Blossom Wilt (<i>Sclerotinia cinerea</i> Schroet.)	do.
Bitter Rot (<i>Glomerella cingulata</i> (Stonem.) Spauld. et v. Schrenk) (on imported fruit).	
Fruit Rot (<i>Phytophthora Syringae</i> Klebahn)	Moray Firth, Nairn
„ (<i>Phytophthora Cactorum</i> (Leh. and Cohn) Schroet. has been suspected, but not proved, in some cases)	
	Edinburgh, locally common
Leaf Blotch (<i>Phyllosticta solitaria</i> Ell. et Everh.)	Ayr (1 case)
Black Rot (<i>Physalospora Cydoniae</i> Arnaud)	Imported
Scorch (Physiological).	
Brown Heart (Storage trouble).	

PEAR.

Scab (<i>Venturia pirina</i> Aderh.)	General
Canker (<i>Nectria galligena</i> Bres.)	Forfar and Ayr
„ (<i>Nectria cinnabarina</i> (Tode) Fr.) (parasitic)	
	Midlothian and Stirling
Blossom Wilt (<i>Sclerotinia cinerea</i> Schroet.)	Blairgowrie, Perth
Leaf Blister (<i>Taphrina bullata</i> (Berk.) Tul.)	Argyll
Leaf Fleck (<i>Septoria piricola</i> Desm.)	Ayr
(Perfect stage is <i>Mycosphaerella sentina</i> (Fr.) Schroet.)	
Sleepiness (Storage trouble).	

PLUM.

Silver Leaf (<i>Stereum purpureum</i> Pers.)	Not very common in Scotland
Blossom Wilt, Wither Tip, and Brown Rot (<i>Sclerotinia cinerea</i> Schroet.)	General
Rust (<i>Puccinia Pruni-spinosae</i> Pers.)	Lothians and Nairn
Scab (<i>Cladosporium carpophilum</i> Thum.= <i>Fusicladium carpo- philum</i> (Thum.) Oud.)	Selkirk
Pocket Plums (<i>Taphrina Pruni</i> (Fuckel) Tul.)	
	Not common, Lothians
Die Back (<i>Diaporthe perniciosu</i> Marchal and <i>Cytosporu</i> sp. associated) doubtfully parasitic.	
Bacterial Canker (<i>Pseudomonas prunicola</i> Wormald)	Clackmannan

CHERRY.

Brown Rot and Blossom Wilt (<i>Sclerotinia cinerea</i> Schroet.)	
	Distributed
Bitter Rot (<i>Glomerella cingulata</i> (Stonem.) Sp. et v. Sch. = <i>G. rufo- maculans</i> (Berk.) Sp. et v. Sch.)	Jura
Witches' Broom (<i>Taphrina Cerasi</i> (Fckl.) Sadeb.)	Lanark
Leaf Curl (<i>Taphrina minor</i> Sadeb.)	do.

PEACH (Glasshouse).

Leaf Curl (<i>Taphrina deformans</i> (Berk.) Tul.)	Distributed
Brown Rot (<i>Sclerotinia cinerea</i> Schroet.)	Lothians (occasional)
Silver Leaf (<i>Stereum purpureum</i> Pers.)	Stirling
Shot Hole (<i>Clasterosporium carpophilum</i> (Lév.) Aderh.)	
	Argyll (rare)

	Locality
Scab (<i>Gladosporium carpophilum</i> Thüm.)	Occasional
Mildew (<i>Sphaerotheca pannosa</i> (Wallr.) Lévl. var. <i>persicae</i> Woron.)	Edinburgh
APRICOT.	
Coral Spot (<i>Nectria cinnabarina</i> (Tode) Fr.)	Fife and Edinburgh
ALMOND.	
Leaf Curl (<i>Taphrina deformans</i> (Berk.) Tul.)	Fife and general
GOOSEBERRY.	
American Mildew (<i>Sphaerotheca mors-uvae</i> (Schw.) Berk.)	General
European Mildew (<i>Microsphaera Grossulariae</i> (Wallr.) Lévl.)	do.
Cluster Cup Rust (<i>Puccinia Pringsheimiana</i> Kleb.)	do.
Leaf Spot (<i>Pseudopeziza Ribis</i> Kleb.)	Common
Die Back (<i>Botrytis cinerea</i> Pers.)	On old bushes
Black Pustule (<i>Plowrightia ribesia</i> (Pers.) Sacc.)	do.
<i>Hendersonia Grossulariae</i> Oudem.	Edinburgh, Glasgow
BLACK CURRANT.	
Reversion (Virus disease)	General
American Mildew (<i>Sphaerotheca mors-uvae</i> (Schw.) Berk.)	Elgin, Perth, etc.
Leaf Spot (<i>Pseudopeziza Ribis</i> Kleb.)	General
Coral Spot (<i>Nectria cinnabarina</i> (Tode) Fr.)	Occasional
Die Back (<i>Botrytis cinerea</i> Pers.)	Forfar, Edinburgh, etc.
Fasciation	Not uncommon
RED CURRANT.	
Leaf Spot (<i>Pseudopeziza Ribis</i> Kleb.)	General
Coral Spot (<i>Nectria cinnabarina</i> (Tode) Fr.)	do.
Black Pustule (<i>Plowrightia ribesia</i> (Pers.) Sacc.)	On old bushes, Lothians, etc.
RASPBERRY.	
Canker (<i>Nectria Rubi</i> Osterw.)	Elgin, Perth
Rust (<i>Phragmidium Rubi-Idaei</i> (Pers.) Karst.)	General
Blue Stripe Wilt (<i>Verticillium Dahliae</i> Kleb.)	Berwick
Die-back (sudden, cause unknown)	Perth, Lanark, etc.
Mosaic (Virus disease)	Perth, etc.
LOGANBERRY.	
Cane Blight (<i>Leptosphaeria Coniothyrium</i> (Fkl.) Sacc.)	Midlothian
Anthraco-se (<i>Plectodiscella veneta</i> Burkh. = <i>Gloeosporium venetum</i> Spég.)	do.
STRAWBERRY.	
Mildew (<i>Sphaerotheca Humuli</i> (DC.) Burr.)	General
Leaf Spot (<i>Mycosphaerella Fragariae</i> (Tul.) Lindau)	do.
Leaf Scorch (<i>Marssonina Fragariae</i> (Sacc.) Kleb.)	do.
Red Core (<i>Phytophthora</i> sp.)	Lanark, Aberdeen, Fife, etc.

GRAPE VINE.

Locality

Powdery Mildew (<i>Uncinula necator</i> (Schw.) Burr.) .	Glasshouses
Grey Mould (<i>Botrytis cinerea</i> Pers.)	do.
Scorch and Shelling (Physiological)	do.

MELON.

Damping-off (<i>Phytophthora</i> sp.)	Fife
--	------

BANANA (Imported).

Soft Rot (<i>Thielaviopsis paradoxa</i> (de Seyn.) v. Höhn.).	
--	--

OLIVES (Stored).

Rot (<i>Monilia</i> sp. and <i>Oidium</i> sp.).	
--	--

ORANGE (Imported).

Fruit Rot (<i>Alternaria citri</i> Pierce).	
--	--

OTHER CITRUS sp.

Sooty Mould (<i>Capnodium</i> sp. and <i>Meliola</i> sp.).	
---	--

FIG (Imported).

Smut (<i>Aspergillus Ficum</i> (P. Henn.) Wehm.= <i>Sterigmatocystis ficum</i> P. Henn.).	
--	--

ROOTS.

SWEDES.

Finger and Toe (<i>Plasmodiophora Brassicæ</i> Woron.) .	General
White Blister (<i>Cystopus candidus</i> (Pers.) de Bary) (Rare). Coldstream	
Dry Rot (<i>Phoma Lingum</i> (Tode) Desm.)	Fairly general
Leaf Spot (<i>Gloeosporium concentricum</i> (Grev.) Berk. et Br.)	Occasional

BEET and SUGAR BEET.

Black Leg (<i>Phoma Betae</i> (Oud.) Frank)	Edinburgh, etc.
Rust (<i>Uromyces Betae</i> (Pers.) Tul.)	Aberdeen, etc.

PULSE.

FIELD and BROAD BEAN.

Chocolate Spot (<i>Bacillus Lathyri</i> Manns et Taub.)	Edinburgh
Rust (<i>Uromyces Fabae</i> (Pers.) de Bary). . . .	Not often reported
Mosaic	do.

FRENCH BEAN.

Anthraxnose (<i>Colletotrichum Lindemuthianum</i> (Sacc. et Magn.)	
Bri. et Cav.)	Occasional

PEAS.

Powdery Mildew (<i>Erysiphe Polygoni</i> DC.)	Distributed
Spot (<i>Ascochyta Pisi</i> Lib.)	General
Anthraxnose (<i>Colletotrichum</i> sp.)	Edinburgh district
Stripe (<i>Pseudomonas seminum</i> Cayley)	Distributed
Root Rot (<i>Aphanomyces euteiches</i> Drechs.)	Aberdeen, Fife, Glasgow
Root Rot (<i>Thielavia basicola</i> Zopf.).	Doubtfully parasitic. Occasional
Mosaic	Rare

VEGETABLES.

BRASSICAE (CABBAGE, CAULIFLOWER), etc.		Locality
Finger and Toe (<i>Plasmodiophora Brassicae</i> Woron.)	.	General
Downy Mildew (<i>Peronospora parasitica</i> (Pers.) Tul.)	.	do.
Powdery Mildew (<i>Erysiphe Polygoni</i> DC.)	.	Distributed
White Blister (<i>Cystopus candidus</i> (Pers.) de Bary)	.	Rare, do.
Damping-off (<i>Pythium</i> sp.)	.	General
Ring Spot (<i>Mycosphaerella brassicicola</i> (Fr.) Lindau)	.	Occasional
Leaf Spot (<i>Gloeosporium concentricum</i> (Grev.) Berk. et Br.)	.	do.
Heart Rot (Physiological, cause unknown)	.	Lothians
Black Rot (<i>Pseudomonas campestris</i> (Pamm.) E.F.S.)	.	West
White Rot (<i>Pseudomonas destructans</i> Pott.)	Occasional in the	West

HORSE RADISH.

White Blister (<i>Cystopus candidus</i> (Pers.) de Bary)	.	Aberdeen
---	---	----------

CUCUMBER.

Stem Rot (<i>Sclerotinia sclerotiorum</i> (Lib.) de Bary)	.	Edinburgh
Wilt (<i>Verticillium albo-atrum</i> Reinke et Berth.)	.	do.
Mildew (<i>Erysiphe Cichoracearum</i> DC.)	.	Aberdeen

VEGETABLE MARROW.

Mildew (<i>Erysiphe Cichoracearum</i> DC.)	Common late in dry seasons,	Aberdeen
Anthraxnose (<i>Colletotrichum oligochaetum</i> Cav.)	.	do.

CELERY.

Soft Rot (<i>Bacillus carotovorus</i> L. R. Jones)	.	Lothians
Leaf Spot (<i>Septoria Apii</i> Chester= <i>S. Petroselinii</i> Desm. var. <i>Apii</i> Bri. et Cav.)	.	General

LETTUCE.

Bacterial Spot (<i>Bacterium pyocyaneum</i> (Gessard) Lehm. et Neum.= <i>B. marginale</i> N. A. Brown)	.	Local
Downy Mildew (<i>Bremia Lactucae</i> Regel)	.	Rare, Lothians
Ring Spot (<i>Marssonina panattoniana</i> Berl.)	.	Common
Grey Mould (<i>Botrytis cinerea</i> Pers.)	Common in wet seasons	

TOMATO.

Damping-off and Foot Rot (<i>Phytophthora cryptogea</i> Peth. et Laff. and <i>P. parasitica</i> Dast.)	.	Common, Lanark
Buck-eye Rot (<i>Phytophthora parasitica</i> Dast.= <i>P. terrestris</i> Sherb.)	Occasional	
Violet Root Rot (<i>Rhizoctonia violacea</i> Tul. and <i>R. Crocorum</i> (Pers.) DC.)	.	do.
Wilts (<i>Verticillium albo-atrum</i> (Reinke et Berth.) and <i>Fusa-</i> <i>rium</i> sp.)	.	Doubtful
Leaf Mould (<i>Cladosporium fulvum</i> Cooke)	.	General

	<i>Locality</i>
Grey Mould (<i>Botrytis cinerea</i> Pers.)	Occasional
Stripe (now considered a virus)	General
Fruit Rots (<i>Phoma destructiva</i> Plowr., <i>Macrosporium solani</i> E. et M., <i>Alternaria</i> sp., and <i>Stemphylium</i> sp.)	Occasional
Blossom End Rot (Physiological)	do.
Mosaic, Aucuba Mosaic, and Fern Leaf Mosaic	Fairly general

ONION.

Downy Mildew (<i>Peronospora Schleideni</i> Unger)	General
Neck Rot (<i>Botrytis Allii</i> Munn)	Rare
White Rot (<i>Sclerotium cepivorum</i> Berk.)	General
Smut (<i>Urocystis Cepulae</i> Frost)	Lothians

LEEK.

White Tip (<i>Phytophthora Porri</i> Foister)	Lothians
White Rot (<i>Sclerotium cepivorum</i> Berk.)	General
Rust (<i>Puccinia Porri</i> (Sow.) Wint.)	do.
Smut (<i>Urocystis Cepulae</i> Frost)	Lothians
Stripe (cause unknown, but Virus suspected)	do.

MINT.

Rust (<i>Puccinia Menthae</i> Pers.)	Common
---	--------

RHUBARB.

Crown Rot (cause unknown, but <i>Pythium</i> sp. and <i>Bacterium</i> sp. associated)	General
--	---------

POTATO.

Early Leaf Blight (<i>Macrosporium Solani</i> E. et M.= <i>Alternaria</i> <i>Solani</i> (E. et M.) Jones et Grout)	Edinburgh
Wilt (<i>Verticillium albo-atrum</i> Reinke et Berth.)	Very rare, do.
Black Dot (<i>Colletotrichum atramentarium</i> (Berk. et Br.) Taub.)	Rare, East Linton
Stalk Break (Stem Rot) (<i>Sclerotinia Sclerotiorum</i> (Lib.) de Bary)	Prevalent in the West

The following were usually reported to the Seed-testing Station :

Skin Spot (<i>Oospora pustulans</i> Owen et Wakef.).
Blight (<i>Phytophthora infestans</i> (Mont.) de Bary).
Common Scab (<i>Actinomyces scabies</i> (Thaxt.) Gussow).
Powdery Scab (<i>Spongospora subterranea</i> (Wallr.) Lagerh.).
Wart Disease (<i>Synchytrium endobioticum</i> (Schilb.) Perc.).
Dry Rot (<i>Fusarium caeruleum</i> (Lib.) Sacc.).
Blackleg (<i>Bacillus phytophthorus</i> Appel= <i>B. atrosepticus</i> van Hall).

FORAGE AND PASTURE CROPS.

CLOVER (WILD WHITE CLOVER).

Leaf Spot (<i>Pseudopeziza Trifolii</i> (Biv.-Bern.) Fckl.).	
Black Blotch (<i>Dothidella Trifolii</i> (Pers.) Bayl.-Ell. et Stans.)	
(<i>Polythrincium</i> stage)	Ayr, Lauder
Rust (<i>Uromyces flectens</i> Lagh.)	Edinburgh

RED CLOVER.

Locality

Mildew (<i>Erysiphe Polygoni</i> DC.)	Ayr, Lothians
Leaf Spot (<i>Pseudopeziza Trifolii</i> (Biv.-Bern.) Fekl.)	Ayr
Scorch (<i>Kabatiella caulivora</i> (Kirchn.) Karak. = <i>Gloeosporium caulivorum</i> Kirchn.)	Ayr, Lothians
Black Blotch (<i>Dothidella Trifolii</i> (Pers.) Bayl.-Ell. et Stans.) (<i>Polythrincium</i> stage).	

ALSIKE.

Leaf Spot (<i>Pseudopeziza Trifolii</i> (Biv.-Bern.) Fekl.)	
Downy Mildew (<i>Peronospora Trifoliorum</i> de Bary)	Lothians, Ayr

BLACK MEDICK.

Leaf Spot (<i>Pseudopeziza Trifolii</i> (Biv.-Bern.) Fekl.)	do., do.
Black Blotch (<i>Dothidella Trifolii</i> (Pers.) Bayl.-Ell. et Stans.) (<i>Polythrincium</i> stage)	do.

COCK'S FOOT.

Rathay's Disease (<i>Aplanobacter Rathayi</i> E. F. Sm.)	Perthshire
---	------------

RYE GRASS.

Ergot (<i>Claviceps purpurea</i> (Fr.) Tul.)	Ayr
---	-----

TIMOTHY GRASS.

Rust (<i>Puccinia Phlei-pratensis</i> Erikss. et Henn.)	do.
--	-----

CEREALS.

(Investigations on Wheat were confined to the Lothians.)

WHEAT.

Mildew (<i>Erysiphe graminis</i> DC.).	
Mould (<i>Macrosporium</i> sp.).	
Whiteheads (<i>Ophiobolus graminis</i> Sacc.).	
Black Rust (<i>Puccinia graminis</i> Pers.).	
Yellow Rust (<i>Puccinia glumarum</i> (Schm.) Eriks. et Henn.).	

OATS.

Black Rust (<i>Puccinia graminis</i> Pers.)	Dumfries and West
Crown Rust (<i>Puccinia Lolii</i> Niels. = <i>P. coronifera</i> Kleb.)	General
Loose Smut (<i>Ustilago Avenae</i> (Pers.) Jens.)	do.
Mildew (<i>Erysiphe graminis</i> DC.)	do.
Grey Spot (<i>Scolecotrichum graminis</i> Fekl.)	Ayr
Moulds (<i>Alternaria</i> sp. and <i>Cladosporium</i> sp.)	Lothians
Leaf Spot or Stripe (<i>Helminthosporium Avenae</i> (Bri. et Cav.) Eid.)	Midlothian and West
Take-All (<i>Ophiobolus graminis</i> Sacc.)	Lothians

BARLEY.

Mildew (<i>Erysiphe graminis</i> DC.)	General
Net Blotch (<i>Pyrenophora teres</i> (Died.) Drechs. = <i>Helminthosporium teres</i> Sacc.)	Midlothian

FLOWERS AND OTHER ORNAMENTAL PLANTS.

ANEMONE.

Locality

Rust (<i>Puccinia Pruni-spinosae</i> Pers.)	Midlothian
Rust (<i>Ochrospora Sorbi</i> Diet. ?)	Edinburgh
Smut (<i>Urocystis anemones</i> (Pers.) Wint.).	

ANTIRRHINUM.

Wilt (<i>Sclerotinia Sclerotiorum</i> (Lib.) de Bary) . . .	Dumfries
Foot Rot (<i>Pythium</i> sp. and <i>Phytophthora</i> sp.) . . .	Aberdeen
Root Rot (<i>Rhizoctonia</i> sp.)	Occasional, Lothians
Stem Rot (<i>Phyllosticta Antirrhini</i> Syd.)	Edinburgh

ASTERS.

Wilt (<i>Phytophthora parasitica</i> Dastur and <i>P. cryptogea</i> Peth. et Laff.)	Glasshouse, Selkirk
<i>Ramularia macrospora</i> var. <i>asteris</i>	Edinburgh

BARBERRY.

Rust (<i>Puccinia graminis</i> Pers.)	Perth, Dumfries, and Lothians
--	-------------------------------

BEGONIA.

Damping-off (<i>Pythium</i> sp. and <i>Phytophthora</i> sp.) . . .	Edinburgh
Leaf Spots (<i>Gloeosporium Begoniae</i> Magna., and <i>Phyllosticta</i> <i>Begoniae</i> Brun.)	do.
Mosaic-like leaves (Physiological).	

BELLADONNA.

Wilt and Root Rot (<i>Phytophthora erythroseptica</i> Peth. var. <i>atropae</i> Alcock)	do.
---	-----

BOG MYRTLE.

Leaf and Twig Blight (<i>Orularia destructiva</i> (Phil. et Plow.) Mass.)	Garelochhead
--	--------------

BOX.

Rust (<i>Puccinia Buxi</i> DC)	Dumfries
---	----------

CALCEOLARIA.

Foot Rot (<i>Phytophthora</i> sp.)	Midlothian
---	------------

CARNATION.

Leaf Rot (<i>Pseudodiscosia Dianthi</i> Host. et Laub.) . . .	Lothians
Rust (<i>Uromyces Dianthi</i> (Pers.) Niessl. — <i>U. Caryophyllinus</i> (Schränk) Schroet.)	do.
Mildew (<i>Oidium</i> sp.)	do.

CHRYSANTHEMUM.

Mildew (<i>Oidium Chrysanthemi</i> Rabenh.)	Edinburgh
Leaf Spot (<i>Phoma Chrysanthemi</i> Vogl.)	Lothians

		Locality
CRINUM.		
Damping-off (<i>Botrytis</i> sp.).		
DAHLIA.		
Black Blight (Fungus disease, not identified)	.	Lothians
Virus (suspected)	.	do.
DELPHINIUM.		
Mildew (<i>Erysiphe Polygoni</i> (DC.) Salm.)	.	do.
FUCHSIA.		
Damping-off (<i>Botrytis</i> sp.)	.	Glasshouses
GLADIOLUS.		
Dry Rot (<i>Sclerotium Gladioli</i> Mass.)	.	Lothians
Storage Rot (<i>Penicillium Gladioli</i> McCull. and Thom)	.	do.
GLOXINIA.		
Wilt (<i>Phytophthora cryptogea</i> (Peth. et Laff.))	.	Glasshouses, do.
HOLLYHOCK.		
Rust (<i>Puccinia Malvacearum</i> Mont.)	.	General
HYACINTH.		
Yellow Disease (<i>Bacterium Hyacinthi</i> Wakk.). (Imported bulbs.)	.	
A Soft Rot (Bacterial) (<i>Bacillus carotovorus</i> L. R. Jones, suspected—not identified)	.	Edinburgh
HYPERICUM ANDROSAEMUM.		
Rust (<i>Melampsora Hypericorum</i> Wint.)	.	Lothians
IRIS.		
Leaf Rot (<i>Pseudomonas Iridis</i> van Hall)	.	Edinburgh
Rust (<i>Puccinia Iridis</i> (DC.) Wallr.)	.	do.
Bulb Rot (<i>Penicillium Gladioli</i> McCull. et Thom) (Storage Rot).	.	
Leaf Spot (<i>Heterosporium gracile</i> Sacc.)	.	do.
LILY.		
Lily Disease (<i>Botrytis elliptica</i> (Berk.) (Ke.)	.	do.
Rosette, Yellow Flat or Bermuda Lily Disease (Virus)	.	do.
MAHONIA.		
Rust (<i>Puccinia mirabilissima</i> (Peck))	.	
The Borders, Fife, Peeblesshire, General in Lothians		
MECONOPSIS sp.		
Mildew (<i>Peronospora arborescens</i> de Bary)	.	Edinburgh
Wilt (<i>Sclerotium</i> sp.)	.	do.

MOSCHATEL (*Adoxa moschatellina*).

Locality

Rust (*Puccinia Adoxae* Hedw. f.) Edinburgh

NARCISSUS.

Smoulder (*Botrytis narcissicola* Kleb.) do.White Mould (*Ramularia Vallisumbrosae* Cav.) do.

PELARGONIUM.

Blackleg (*Pythium* sp.) BordersGrey Mould (*Botrytis cinerea* Pers.) Common

White Spots and Mottling (Physiological).

PETUNIA.

Foot Rot (*Phytophthora cryptogea* Peth. et Laff.) Edinburgh

PHLOX.

Damping-off (*Phytophthora parasitica* Dastur) do.

POLYPODIUM IROIDES.

Leaf Spot (*Sphaerella aquilina* (Fr.) Awd.) do.

PRIVET.

Honey Agaric (*Armillaria mellea* (Vahl.) Fr.) do.

RHODODENDRON.

Gall (*Erobasisidium Vaccinii* (Fekl.) Woron.) Lothians, Ayr, etc.Leaf Scorch (*Sporocybe Azaleae* (Peck) Sacc.) EdinburghStem Canker (*Botrytis* sp.) ArgyllSooty Mould (*Meliola* sp.) Edinburgh

ROSE.

Black Spot (*Diplocarpon Rosae* Wolf.—*Actinonema Rosae* (Lib.) Fr.) GeneralMildew (*Sphaerotheca pannosa* (Wallr.) Lév.) do.Rust (*Phragmidium mucronatum* (Pers.) Schlecht — *P. disciflorum* James and *P. subcorticium* Wint.) do.Graft Canker (*Coniothyrium Rosarum* (Uke. et Harkn.)) Edinburgh

SCILLA.

Smut (*Ustilago Vaillantii* Tul.) do.

STOCK.

Downy Mildew (*Peronospora parasitica* (Pers.) Tul.) LothiansWilt (*Phytophthora cryptogea* Peth. et Laff.) do.Stem Rot (*Rhizoctonia Solani* Kühn) do.

SWEET PEA.

Locality

Mildew (<i>Peronospora Viciae</i> (Berk.) de Bary)	.	.	Occasional
Streak (<i>Bacillus Luthyri</i> Manns. et Taub.)	.	.	General
Root Rot (<i>Aphanomyces euteiches</i> Drechsl.)			
	Aberdeen, Glasgow, Edinburgh		
Leaf Spot (<i>Ascochyta Pisi</i> Lib.)	.	.	Edinburgh

TULIP.

Shanking (<i>Phytophthora cryptogea</i> Peth. et Laff.)	.	Ayr, Lothians
Fire (<i>Botrytis Tulipae</i> (Lib.) Lind.)	.	General
Grey Bulb Rot (<i>Rhizoctonia Tuliparum</i> (Kleb.) Whetz. et Arth.= <i>Sclerotium Tuliparum</i> Kleb.)	.	Edinburgh
Rust (<i>Puccinia Prostii</i> Mong.)	.	do.
Storage Rot (<i>Penicillium</i> sp.)	.	
Glenmoriston Disease (<i>Cercospora</i> sp.)	.	Inverness

VERONICA CHAMAEDRYS.

Root Gall (<i>Sorosphaera Veronicae</i> Schroet.)	.	Aberdeen
--	---	----------

VIOLA.

Root Rot (<i>Aphanomyces</i> sp.)	.	Lothians
Rust (<i>Puccinia aegra</i> Grove)	.	Edinburgh
Mildew (<i>Oidium</i> sp.)	.	Lothians
Dry Rot (<i>Phoma violae-tricoloris</i> (Died.))	.	do.

WALLFLOWER.

Finger and Toe (<i>Plasmodiophora Brassicae</i> Woron.)	.	Edinburgh
Downy Mildew (<i>Peronospora parasitica</i> (Pers.) Tul.)	.	General
Damping-off (<i>Pythium</i> sp.)	.	Fife

ZINNIA.

Foot Rot (<i>Phytophthora cryptogea</i> Peth. et Laff.)	.	Lothians
--	---	----------

CONIFERS.

ABIES PECTINATA.

Die Back (<i>Rehmiellopsis bohémica</i> Bub. et Kab.)	.	West of Scotland, Forres
Witches' Broom (<i>Melampsoralla caryophyllacearum</i> Schroet.)		Distributed

DOUGLAS FIR.

Leaf Cast (<i>Rhabdochline Pseudotsugae</i> Sydow)	.	Borders
---	---	---------

SCOTS PINE.

Canker (<i>Dasyctypha</i> sp.)	.	St. Andrews
Leaf Cast (<i>Lophodermium pinastri</i> (Schr.) Chev.)	.	General

SPRUCE.

Rust (<i>Chrysomyxa abietis</i> Unger)	.	Selkirk
---	---	---------

THUJA PLICATA.

Locality

<i>Keithia thujina</i> Durand	Distributed
-------------------------------	-----------	-------------

YEW.

Leaf Scorch (<i>Sphaerulina Taxi</i> Mass.)	do.
--	-----------	-----

BROAD-LEAVED TREES.

ASH.

Canker (<i>Nectria galligena</i> Bres.)	. . . . .	Fife (distributed)
Bacterial Canker	. . . . .	Fife and Borders

BEECH.

Canker (<i>Nectria coccinea</i> (Pers.) Fr.)	Distributed
---	-----------	-------------

HAWTHORN.

Mildew (<i>Podosphaera Oxyacanthae</i> (DC.) de Bary)	General
--	-----------	---------

LABURNUM.

Branch Canker (<i>Calonectria Pseudopeziza</i> (Desm.) Sacc.)	Edinburgh
<i>Cucurbitaria Laburni</i> de Not.	Lothians

LILAC.

Wilt (<i>Phytophthora Syringae</i> Kleh.)	Edinburgh
--	-----------	-----------

POPLAR.

Leaf Curl (<i>Taphrina aurea</i> Sade.)	. . . . .	General
Rust (<i>Melampsora Larici-populina</i> Lev.)	. . . . .	do.
Brown Slime Flux (<i>Bacteria</i>)	. . . . .	Fifeshire (common)

ROWAN.

Silver Leaf (<i>Stereum purpureum</i> Pers.)	Edinburgh
---	-----------	-----------

SYCAMORE.

Scorch (<i>Gnomonia veneta</i> (Sacc. et Speg.) Kleh.)	. . . . .	Kirkcaldy
Tar Spot (<i>Rhytisma acerinum</i> (Pers.) Fr.)	. . . . .	Common

WILLOW.

Scab (<i>Fusicladium saliciperdu</i> (All. et Tub.))	. . . . .	Beauly
Stem Blister (<i>Cryptomyces maximus</i> (Fr.) Rehm.)	. . . . .	do.
Branch Disease (<i>Scleroderris fuliginosa</i> Karst.)	. . . . .	do.
„ „ (<i>Myrosporium scutellatum</i> Otth. (Petrak))	. . . . .	do.

MISCELLANEOUS.

HEATHER.

	<i>Locality</i>
Honey Agaric (<i>Armillaria mellea</i> (Vahl.) Fr.) . . .	Arran

HOP (Wild).

Mildew (<i>Sphaerotheca Humuli</i> (DC.) Burr.) . . .	Dumfries
--	----------

TOBACCO (Imported).

Mould (*Botrytis longibrachiata* Oud.).

Mildew (*Peronospora Nicotianae* Speg.).

TURF.

Brown Patch (*Corticium fusiforme* (Berk.) Wakef.

On golf and other greens, Lothians

Puff Ball (*Bovista plumbea* Pers.) . . . On golf greens

OBITUARY NOTICE.

WILLIAM CARMICHAEL M'INTOSH.
1838-1931.

Natural Science lost one of its noblest exponents with the death of Professor William Carmichael M'Intosh on 1st April 1931. Dr. M'Intosh, as he then was, joined the Botanical Society of Edinburgh in 1880, two years before he was called to the Chair of Natural History in his Alma Mater, St. Andrews.

Previously he was Medical Superintendent of Murthly Institution, and the beauty of the Perthshire estates which surrounded the Institution influenced his choice and development of Neeve Park, his summer residence in later years. Though pre-eminently a marine zoologist, Professor M'Intosh maintained throughout his life his interest in plants.

Accounts of his contributions to Natural Science, and the many distinctions which accrued to him through their publication, have appeared elsewhere. Of all the honours he received none was appreciated more highly by himself than the award of the Linnean Gold Medal in 1924.

A student first of St. Andrews University, Professor M'Intosh graduated in Medicine at Edinburgh University. It is at the former University that his name is remembered with gratitude for the great interest he took in the welfare of the students. He held not only the respect and admiration but also the affection of all who knew him.

To the end, in his ninety-third year, he retained his mental faculties unimpaired, and up to the last was a keen research student. He was a strenuous worker, regulating his labours by time-table. In consequence of this in his leisure he found time to help others, and it was only last winter that he contributed personal notes on past presidents of the Botanical Society, which it is intended to utilise at the centenary of the Society of which for over fifty years he was a loyal member.

R. J. D. GRAHAM.

ROLL

OF

THE BOTANICAL SOCIETY OF EDINBURGH.

Corrected to September 1931.

Patron:

HIS MOST GRACIOUS MAJESTY THE KING.

HONORARY FELLOWS.

BRITISH SUBJECTS (LIMITED TO SIX).

Date of Election.

- June 1923. DRUCE, G. CLARIDGE, M.A., LL.D., F.R.S., 9 Crick Road, Oxford.
- Dec. 1907. FARMER, Sir JOHN BRETLAND, M.A., D.Sc., F.R.S., *Professor of Botany, Imperial College of Science and Technology, S. Kensington.*
- Dec. 1930. LANG, WILLIAM HENRY, M.B., C.M., D.Sc., F.R.S., *Barker Professor of Cryptogamic Botany, University of Manchester.*
- June 1923. PRAEGER, R. LLOYD, B.A., D.Sc., *National Library of Ireland, Kildare Street, Dublin.*
- June 1923. RENDLE, A. B., M.A., D.Sc., F.R.S., "Talland," *The Mount, Fetcham Park, Leatherhead, Surrey.*
- Feb. 1912. SCOTT, D. H., M.A., LL.D., Ph.D., F.R.S., *East Oakley House, Basingstoke, Hants.*

FOREIGN (LIMITED TO TWENTY-FIVE).

- June 1902. BRITTON, NATHANIEL LORD, *care of the Botanic Garden, New York.*
- June 1923. CAMPBELL, Dr. DOUGLAS HOUGHTON, *Professor of Botany, Stanford University, California;—Corresponding Member, Dec. 1905.*
- June 1923. CHODAT, Professor Dr. ROBERT, *L'Université, Geneva.*
- Feb. 1911. FLAHAULT, Dr. CHARLES, *Professor of Botany to the Faculty of Science, and Director of the Institute of the University, Montpellier.*
- June 1923. IKENO, Professor SEITTSIRO, Ph.D., *Agricultural College, Imperial University, Tokio.*
- June 1923. LECOMTE, Professor HENRI, *Muséum d'Histoire Naturelle, Paris.*
- June 1923. LOTSY, Dr. J. P., *Spaarne 17, Haarlem.*
- June 1923. MACDOUGAL, Dr. D. T., *Director of Department of Botanical Research, Carnegie Institution, Tucson.*

Date of Election.

- June 1923. OSTERHOUT, W. J. V., Ph.D., *Rockefeller Institute, 66th Street and Avenue A., New York.*
 June 1923. THAXTER, PROFESSOR ROLAND, Ph.D., *7 Scott Street, Cambridge, Mass.*
 June 1902. TRELEASE, DR. WILLIAM, *University of Illinois, Urbana, Illinois, U.S.A.*
 Mar. 1895. VRIES, DR. H. DE, *Professor of Botany in the University, Amsterdam.*

ORDINARY FELLOWS.

No distinguishing mark is placed before the name of Fellows who contribute annually and receive Publications.

* Indicates Fellows who have compounded for Annual Contribution and receive Publications.

† Indicates Non-Resident Fellows who have compounded for Publications.

‡ Indicates Non-Resident Fellows who do not receive Publications.

Date of Election.

- Dec. 1915. Adam, Robert Moyes, *17 W. Brighton Crescent, Portobello.*
 Feb. 1905. †Aiken, Rev. J. J. Marshall Lang, B.D., *The Manse, Ayton, Berwickshire.*
 Jan. 1924. Aitken, Mrs. W., *2 Sycamore Terrace, Corstorphine.*
 Nov. 1924. *Alcock, Mrs. N. L., F.L.S., *14 Inverleith Row, Edinburgh.*
 Feb. 1931. Allardyce, G. L., W.S., *25 Rutland Street, Edinburgh.*
 Feb. 1925. Anderson, J. B., *76 South Trinity Road, Edinburgh.*
 Nov. 1926. *Anthony, John, M.C., M.A., B.Sc., *7 Craigcrook Gardens, Edinburgh.*
 Dec. 1924. Armstrong, D., *The Drum, Gilmerton, Midlothian.*
 Dec. 1908. ‡Balfour, F. R. S., M.A., *39 Phillimore Gardens, Kensington, London, W.*
 May 1891. *Berwick, Thomas, *56 North Street, St. Andrews.*
 Feb. 1919. †Blackburne, Cecil Ireland, *Ashurst, Fernhurst, near Haslemere, Surrey.*
 April 1926. Blackie, John Joseph, Ph.C., *104 Holyrood Road, Edinburgh.*
 May 1888. *Bonnar, William, *51 Braid Avenue, Edinburgh.*
 Jan. 1899. *Borthwick, A. W., O.B.E., D.Sc., *Professor of Forestry, The University, Aberdeen.*
 Dec. 1886. *Bower, F. O., M.A., D.Sc., F.R.S., F.L.S., *2 The Crescent, Ripon.*
 Mar. 1927. Boyd, Miss Lucy, D.Sc., *3 West Brighton Crescent, Portobello.*
 April 1913. ‡Brebner, James, *2 Scotswood Terrace, Dundee.*
 Feb. 1928. Brodie, John A., *16 Montagu Terrace, Edinburgh.*
 Nov. 1929. Brown, Alex. B., B.Sc., *Dept. of Botany, University of Alberta, Edmonton, Canada.*
 May 1924. †Brown, Miss Helen M., *Longformacus, Duns.*
 Dec. 1906. †Bryce, George, D.Sc., *Dept. of Agriculture, Ibadan, Nigeria.*
 Nov. 1922. Buchanan, E. M., *76 Warrender Park Road, Edinburgh.*
 Dec. 1921. †Burns, W., D.Sc., *Bombay Agric. Dept., Poona, Bombay, India.*
 Oct. 1928. Burrell, Sir William, *Hutton Castle, Berwick-on-Tweed.*
 Dec. 1924. †Burt, Miss C. C., B.Sc., *36 Ravenshaugh Road, Levenhall, Musselburgh.*
 Dec. 1915. Cadman, Miss Elsie, M.A., B.Sc., Ph.D., *College of Agriculture, 13 George Square, Edinburgh.*
 Oct. 1926. *Callender, Wm. C., *Georgiefield, 31 Inverleith Terrace, Edinburgh.*
 April 1926. Cardross, The Rt. Hon. Lord, *Almondell House, Mid-Calder.*
 Dec. 1928. Clarke, Robert R., B.Sc., *Whitehall, Aberdeen, Fife.*
 April 1913. Cooper, R. E., *Royal Botanic Garden, Edinburgh.*
 Mar. 1900. *Cowan, Alexander, *Valleyfield, Penicuik.*
 Oct. 1930. Cowan, John M., M.A., D.Sc., *17 Inverleith Place, Edinburgh.*
 June 1929. Cowan, Robert Craig, *Eskhill, Musselburgh.*
 Feb. 1923. †Cox, E. H. M., *32 Old Bond Street, London, W. 1.*
 Dec. 1915. *Craib, W. G., M.A., *Professor of Botany, Aberdeen.*
 Jan. 1922. *Dales, Mrs. H., M.A., B.Sc., *Allora, Kensington Gardens, Knock, Belfast.*
 Oct. 1926. Davey, V. E. M., B.Sc., Ph.D., *Plant Breeding Station, Corstorphine.*
 Dec. 1903. Davidson, J. Randolph, M.A., B.Sc., *49 Meadway Court, Golders Green, London, N.W. 11.*
 Dec. 1911. ‡Davidson, John, *Assistant Professor of Botany, University of British Columbia, Vancouver, Canada.*

Date of Election.

- Dec. 1892. Day, T. Cuthbert, F.I.C., 36 *Hillside Crescent, Edinburgh.*
 Nov. 1925. De Free, Mrs., *Beach Hill, Haddington.*
 Dec. 1930. Dickson, Miss A. M., *Woodhouse, Dunscore, Dumfriesshire.*
 Nov. 1927. *Dobson, Miss Margaret Cairns, 8 *Polwarth Terrace, Edinburgh.*
 Nov. 1919. *Downie, Miss D. G., B.Sc., 1 *W. Stanhope Place, Edinburgh.*
 May 1921. Drummond, J. Montagu F., M.A., F.L.S., *Harrison Professor of Botany, University of Manchester.*
 Feb. 1931. Egerton, Major-General Granville, 7 *Inverleith Place, Edinburgh.*
 Feb. 1917. †Eley, Charles, *East Bergholt Place, Suffolk.*
 Nov. 1885. Elliot, G. F. Scott, M.A., B.Sc., *Howpathay, Cowday Wood, Wadhurst, Sussex.*
 Jan. 1883. *Evans, Arthur H., Sc.D., *Cheviot House, Crowthorne, Berks.*
 Dec. 1905. *Evans, W. Edgar, B.Sc., 38 *Morningside Park, Edinburgh.*
 Dec. 1927. Fenton, E. Wyllie, M.A., B.Sc., F.L.S., F.E.S., 16 *Wilton Road, Edinburgh.*
 Oct. 1928. Foister, Charles Edward, B.A., Ph.D., c/o Hodgkinson, 15 *Goldenacre Terrace, Edinburgh.*
 Feb. 1928. Forrest, Mrs. George, *Bellfield, Bonnyrigg Road, Eskbank, Midlothian.*
 Feb. 1931. Fortune, T. A. S., *Cairngreen, Davidson's Mains, Edinburgh.*
 Jan. 1906. *Fraser, James, 18 *Park Road, Leith.*
 Oct. 1920. *Galloway, R. Angus, M.C., B.Sc., 81 *Cluny Gardens, Edinburgh.*
 Dec. 1920. †Garnock, John, M.A., B.Sc., *Morgan Academy, Dundee.*
 May 1903. †Gilmore, Dr. Owen, L.R.C.P., L.R.C.S.E., 49 *Acre Lane, Brixton, London, S.W. 2.*
 Dec. 1907. Gourlay, Dr. W. Balfour, M.C., 7 *Millington Road, Cambridge.*
 Nov. 1921. *Graham, R. J. D., M.A., D.Sc., 45 *Stirling Road, Edinburgh.*
 Mar. 1923. Gray, John H., M.A., B.Sc., 28 *W. Relugas Road, Edinburgh.*
 Jan. 1926. Gregor, James W., Ph.D., F.L.S., *Craig's House, Corstorphine.*
 Mar. 1925. *Grieve, Miss Jean E., 11 *Lauder Road, Edinburgh.*
 Dec. 1895. *Grieve, Sommerville, 21 *Queen's Crescent, Edinburgh.*
 Feb. 1879. *Grieve, Symington, 11 *Lauder Road, Edinburgh.*
 Nov. 1914. †Harley, Andrew, *Blinkbonny, Kirkealdy.*
 Dec. 1923. †HARRIS, Mrs. K., B.Sc., *Hazeldene, Stretton Avenue, Cambridge.*
 April 1910. Harvey, Miss Elsie, *Kerala, Captains Road, Liberton, Edinburgh.*
 Mar. 1913. †Hayward, Miss Ida M., F.L.S., 7 *Abbotsford Road, Galashiels.*
 Dec. 1929. Heddlie, R. G., M.A., B.Sc., 13 *George Square, Edinburgh.*
 May 1924. †Henderson, George, B.Sc., *Keith Grammar School, Keith, Banffshire.*
 April 1886. Hill, J. Rutherford, Ph.C., *Secretary, Pharmaceutical Society, 36 York Place, Edinburgh.*
 Oct. 1926. †Home, Miss Logan, *Edrom House, Edrom, Berwickshire.*
 June 1927. †Hornel, E. A., *Broughton House, Kirkcudbright.*
 Mar. 1920. Howison, Andrew, M.A., B.Sc., 18 *Beresford Avenue, Leith.*
 May 1925. Im Thurn, Sir Everard, K.C.M.G., K.B.E., *Cockenzie House, Prestonpans.*
 Dec. 1907. *Jeffrey, J. Frederick, *Laneside, Shipham, Winscombe, Somerset.*
 Oct. 1925. Johnston, Miss, *Aros, Colinton.*
 May 1877. *Johnston, Henry Halcro, C.B., C.B.E., D.Sc., M.D., F.L.S., *Colonel R.A.M.C., Mackay's Hotel, Stromness, Orkney.*
 Dec. 1912. *Johnstone, James Todd, M.A., B.Sc., *Royal Botanic Garden, Edinburgh.*
 Mar. 1925. Kean, Miss C. I., B.Sc., Ph.D., *Botanical Dept., University of St. Andrews.*
 Jan. 1913. *Kemp, Mrs. C. Norman, M.A., D.Sc., *Ivy Lodge, Laverockbank Road, Leith.*
 Nov. 1924. *King, Miss C. A., *Osborne Nursery, Corstorphine Road, Edinburgh.*
 Oct. 1921. King, Miss Isabella M., B.Sc., 4 *Cambridge Gardens, Edinburgh.*
 Jan. 1924. *Knox, Mrs. J., M.A., B.Sc., 13 *Dalhousie Terrace, Edinburgh.*
 Nov. 1921. *Laing, Ernest V., M.A., D.Sc., 13 *Belvedere Street, Aberdeen.*
 Dec. 1911. *Lamont, Miss Augusta, 73 *Falcon Road, Edinburgh.*
 Nov. 1927. Lang, J. M. S., B.S.A., *Craig's House, Corstorphine.*
 May 1931. Latham, H. A., 27 *Organgs Road, Lothianburn, Edinburgh.*
 Dec. 1917. Law, Mrs. John, 41 *Heriot Row, Edinburgh.*
 Dec. 1922. *Lewis, Herbert M., B.Sc., *Penucha, Carwys, N. Wales.*
 Oct. 1925. †Low, Wm., *Balmakewan, Marykirk, Montrose.*
 Nov. 1922. †McCall, David, B.Sc., Ph.D., *Dundee Technical College, Bell Street, Dundee.*
 Feb. 1925. Macdonald, James, B.Sc., 25 *Drumsheugh Gardens, Edinburgh.*

Date of Election.

- Jan. 1895. MacDougall, R. Stewart, M.A., D.Sc., *Ivy Lodge, Gullane, East Lothian.*
- Jan. 1881. †Macfarlane, John M., Sc.D., LL.D., F.R.S.E., *Emeritus-Professor of Botany, 427 West Hansberry Street, Germantown, Pa., U.S.A.*
- Feb. 1886. M'Glashan, D., *Kingscroft, Cramond Bridge.*
- Dec. 1925. *M'Intosh, A. E. S., B.Sc., Ph.D., *Assistant Geneticist, Dept. of Science and Agriculture, Barbados, B.W.I.*
- Dec. 1925. Mackie, Miss A. W., *11 Bellevue Terrace, Edinburgh.*
- June 1897. †Macvicar, Symers M., *Invermoidart, Acharacle, Argyllshire.*
- Feb. 1914. Macwatt, John, M.B., C.M., *Morelands, Duns.*
- Dec. 1896. †Mahalanobis, Professor S. C., B.Sc., F.R.S.E., P. 45, *New Park Street, Calcutta.*
- Oct. 1928. Martin, Mrs. Agnes D., c/o The Very Rev. Dr. T. Martin, *Neidpath, Davidson's Mains.*
- Oct. 1914. *Martin, Miss Isa, M.A., *Hillview, Aberdour Road, Dunfermline.*
- Mar. 1913. *Matthews, James R., M.A., *Professor of Botany, The University, Reading.*
- Dec. 1916. †Maxwell, Sir John Stirling, Bart., *Pollok, Pollokshaws, Glasgow.*
- Oct. 1925. Mercer, Miss Edith, *10 Ventnor Terrace, Edinburgh.*
- April 1919. †Mills, A. E., *37 High Street, Keynsham, near Bristol.*
- Dec. 1930. Murhead, Charles, *32 Inverleith Place, Edinburgh.*
- Nov. 1929. Murray, Miss F. B., M.A., *Royal Botanic Garden, Edinburgh.*
- Oct. 1918. †Murray, J. M., B.Sc., *25 Drumsheugh Gardens, Edinburgh.*
- Oct. 1930. Murray, Robert., F.F.S., *11 Murrayfield Gardens, Edinburgh.*
- Dec. 1923. *Nelson, Alex., B.Sc., Ph.D., *Royal Botanic Garden, Edinburgh.*
- April 1916. †Nicholson, C., F.E.S., "*Nansgwillick*," *Tresillian, Probus, Cornwall.*
- Feb. 1894. Novar, The Rt. Hon. Viscount, G.C.M.G., *of Raith and Novar, Kirkcaldy.*
- Dec. 1907. *Orr, Matt. Y., *Royal Botanic Garden, Edinburgh.*
- Feb. 1928. Owen, John Lewis, M.B., D.P.H., *36 Inverleith Row, Edinburgh.*
- Oct. 1914. †Patton, Donald, M.A., B.Sc., Ph.D., *15 Jordanhill Drive, Glasgow, W. 3.*
- Nov. 1919. Pealling, Robert J., M.A., B.Sc., *The Royal Academy, Inverness.*
- Dec. 1917. *Pike, J. Lyford, B.Sc., *Rosetta, Liberton.*
- Jan. 1915. *Pinkerton, A. A., *Adele Cottage, Loanhead.*
- June 1891. †Prain, Sir David, M.D., C.I.E., F.R.S.S.L. & E., F.I.S., *The Well Farm, Warlingham, Surrey.*
- Oct. 1927. Reid, Mrs. Murray, *Easter Belmont, Murrayfield, Edinburgh.*
- April 1877. †Riddell, Wm. R., B.A., B.Sc. (Hon. Mr. Justice), *Osgoode Hall, Toronto, Canada.*
- Feb. 1926. Robb, William, N.D.A., *Craig's House, Corstorphine.*
- Dec. 1890. Robertson, Professor Robert A., M.A., B.Sc., *Botany Dept., The University, St. Andrews.*
- Jan. 1923. †Rollo, Hon. Bernard F., *Keltie Castle, Dunning.*
- Mar. 1925. †Rothschild, Lionel N. de, *Exbury, near Southampton.*
- Mar. 1902. Sampson, Hugh C., C.I.E., B.Sc., *Royal Botanic Gdns., Kew, Surrey.*
- May 1926. †Sangster, Mrs. Iris, *Fullerswood Park, Mountain Side P.O., Jamaica.*
- Dec. 1887. †Scott, J. S., L.S.A., *69 Clowes Street, West Gorton, Manchester.*
- Dec. 1922. Seaton, Ian W., B.Sc., *Plant Breeding Station, Stormont, Stranstown, Belfast.*
- June 1922. †Simpson, J. R., *15 Highfield Crescent, Baildon, Yorks.*
- Dec. 1922. Smith, Miss Edith Philip, B.A., Ph.D., F.L.S., *46 Murrayfield Avenue, Edinburgh.*
- Nov. 1926. †Smith, H. Guthrie, *Tutira, Napier, New Zealand.*
- Nov. 1914. *Smith, James J. S., M.A., B.Sc., *29 Wardie Road, Edinburgh.*
- Feb. 1891. *Smith, J. Pentland, *The Hermitage, Pitvenneem, Fife.*
- Dec. 1917. †Smith, J. T., *68 Tennant Street, Glasgow.*
- Jan. 1902. *Smith, Professor W. Wright, M.A., *King's Botanist, Regius Keeper, Royal Botanic Garden, Edinburgh.*
- Jan. 1890. *Somerville, Sir William, K.B.E., D.Sc., D.Ec., *Rye House, Foxcombe Hill, near Oxford.*
- Jan. 1925. Somerville, Charles W., *Gracemount, Liberton, Edinburgh.*
- Oct. 1930. Steel, William B., *Astley-Ainslie Institution, Grange Loan, Edinburgh.*
- Nov. 1923. †Stern, Frederick, *Highdown, Goring-on-Sea.*
- Dec. 1923. Steven, H. M., B.Sc., Ph.D., *20 Alderman's Drive, Peterborough.*
- Oct. 1923. †Stevenson, J. B., *Tower Court, Ascot.*
- Oct. 1914. †Stewart, Edward J. A., M.A., B.Sc., *8 Manor Road, Jordanhill, Glasgow.*

Date of Election.

- April 1921. Sutherland, John, C.B.E., LL.D., 11 *Inverleith Row, Edinburgh.*
 May 1928. Sutherland, Mrs. Kate, 11 *Inverleith Row, Edinburgh.*
 Feb. 1902. Tagg, Harry F., F.L.S., *Royal Botanic Garden, Edinburgh.*
 Jan. 1913. †Tagg, M. H., 53 *Clayton Avenue, Wembley, Middlesex.*
 Oct. 1926. *Taylor, George, B.Sc., *Dept. of Botany, British Museum (Nat. Hist.), Cromwell Road, London, S.W. 7.*
 Dec. 1922. †Taylor, George Crosbie, B.Sc., F.L.S., 20 *Tavistock Street, Covent Garden, London, W.C. 2.*
 Dec. 1923. †Taylor, James, M.A., B.Sc., *The Academy, Kirkcudbright.*
 May 1923. †Taylor, R. A., M.A., B.Sc., *Rubber Research Station, Mundakayam, Travancore, S. India.*
 Oct. 1929. Terras, Mrs. Kate R., 40 *Findhorn Place, Edinburgh.*
 April 1921. †Thompson, Professor J. MacLean, M.A., D.Sc., F.L.S., *Dept. of Botany, The University, Liverpool.*
 Oct. 1928. Thomson, Miss Norah M'Nab, 30 *Drumshough Gardens, Edinburgh.*
 Dec. 1930. Torbeck, H. C., 53 *Manor Place, Edinburgh.*
 Nov. 1922. *Urquhart, Mrs. Douie, 42 *India Street, Edinburgh.*
 Oct. 1918. †Watson, Harry, *Benmore Forest School, Dunoon, Argyll.*
 Mar. 1925. *Watt, James, LL.D., W.S., 28 *Charlotte Square, Edinburgh.*
 April 1930. *Watt, Mrs. Menie, *Craiglockhart House, Craiglockhart Avenue, Edinburgh, W.*
 Nov. 1921. *Watt, Miss Janet, 2 *W. Catherine Place, Edinburgh.*
 Dec. 1930. Whyte, James H., B.Sc., *Botany Dept., McGill University, Montreal, Canada.*
 Dec. 1922. Wilson, Miss Dorothy G., B.Sc., *Secondary School for Girls, Stockton-on-Tees.*
 Feb. 1912. *Wilson, Malcolm, D.Sc., *Brentknoll, Kinnear Road, Edinburgh.*
 Mar. 1909. *Wilson, Thos., Ph.C., 110 *High Street, Burntisland.*
 Jan. 1903. Young, William, *Fairview, Kirkcaldy.*
 Jan. 1923. *Younger, Harry Geo., *Killoes, Bishopsteignton, S. Devon.*

ORDINARY MEMBERS.

- Dec. 1930. Bowden, J., 26 *Hugh Miller Place, Edinburgh.*
 Nov. 1928. Bruce, Michael, *Cowan House, George Square, Edinburgh.*
 Nov. 1928. Campbell, Alex. H., B.Sc., 22 *Belmont Gardens, Murrayfield, Edinburgh.*
 Nov. 1926. Clark, Miss J. S., B.Sc., 4 *Bruntsfield Terrace, Edinburgh.*
 Nov. 1930. Cowan, Mrs., 17 *Inverleith Place, Edinburgh.*
 Nov. 1926. Drysdale, Miss D., *Royal Botanic Garden, Edinburgh.*
 Nov. 1927. Evans, Miss, 38 *Morningside Park, Edinburgh.*
 Feb. 1928. Forrest, John Eric, *Bellfield, Bonnyrigg Road, Eskbank, Midlothian.*
 Dec. 1929. Gilliland, H. B., 116 *Craiglea Drive, Edinburgh.*
 Nov. 1930. Gray, Miss Effie R., 13 *Leopold Place, Edinburgh.*
 Nov. 1922. Gregor, Mrs. Mary J. F., B.Sc., Ph.D., *North Clermiston House, Cramond Bridge, West Lothian.*
 April 1925. Knott, Eric, 21 *Stevenson Road, Edinburgh.*
 Feb. 1930. Lamb, Ivan M., 2 *Abercorn Avenue, Willowbrae, Edinburgh.*
 Feb. 1931. Macdonald, Jas. A., B.Sc., *Cowan House, George Square, Edinburgh.*
 April 1925. M'Ilvenna, Wm. R., 8 *Inverleith Terrace, Edinburgh.*
 Nov. 1926. MacLachlan, Miss C. M., B.Sc., 13 *South Gray Street, Edinburgh.*
 Nov. 1928. MacLagan, Miss J. F. A., B.Sc., c/o Strong, 7 *Gilmore Place, Edinburgh.*
 Nov. 1930. M'Martin, A., B.Sc., 24 *Burcleuch Place, Edinburgh.*
 Nov. 1928. Murray, John, *Whitlade, Broughton, Peebleshire.*
 Feb. 1928. Pearson, Miss Peggy, *Otterburn, Kelso.*
 Nov. 1930. Petrie, Miss M. S., *Peffermill Cottage, Craigmillar, Edinburgh.*
 Nov. 1930. Pierce, F., c/o M'Murtrie, 20 *Lauriston Gardens, Edinburgh.*
 Nov. 1926. Redman, Miss A. W. H., B.Sc., 30 *Lomond Road, Leith.*
 April 1925. Robertson, Frederick W., 23 *Inverleith Place, Edinburgh.*
 April 1927. Robertson, J. R., 30 *Mayfield Terrace, Edinburgh.*
 April 1925. Robertson, Mrs. Marjory F., 23 *Inverleith Place, Edinburgh.*
 April 1930. Robson, Thomas, 6 *Kirkhill Road, Edinburgh.*
 Nov. 1922. Seaton, Mrs., *Plant Breeding Station, Belfast.*
 Nov. 1930. Smart, J. B., 4 *Chalmers Crescent, Edinburgh.*

Date of Election.

- Nov. 1926. Smith, Miss M. H., B.Sc., *Inverleith House, Edinburgh.*
 April 1925. Smith, Thomas Arthur, 39 *Restalrig Road, Leith.*
 Oct. 1927. Stevenson, Miss J. J., 81 *Trinity Road, Edinburgh.*
 April 1929. Thomsen, Charles, 9 *Denham Green Terrace, Edinburgh.*
 Dec. 1923. Wallace, G. B., B.Sc., Ph.D., 9 *Graham Street, Edinburgh.*
 Dec. 1929. Weber, H. A., 1 *Eyre Place, Edinburgh.*
 June 1928. Williams, Prof. Basil, M.A., 34 *Drummond Place, Edinburgh.*
 June 1928. Williams, Mrs. Dorothy, 34 *Drummond Place, Edinburgh.*

ASSOCIATES.

- Oct. 1927. Forrest, George, V.M.H., *Bellfield, Bonnyrigg Road, Eskbank, Midlothian.*
 Jan. 1906. Harrow, R. L., Director, *Royal Horticultural Society's Gardens, Wisley, Ripley, Surrey.*
 Feb. 1919. Johnson, Norman M., B.Sc., *Ardgarth, Victoria Terrace, Dunfermline.*
 Jan. 1906. Stewart, L. B., *Royal Botanic Garden, Edinburgh.*

LADY MEMBERS.

- June 1893. Aitken, Mrs. A. P., 15 *Victoria Mansions, West Hampstead, London, N.W.*
 April 1893. Balfour, Lady Bayley, *Penfold's Corner, Haslemere, Surrey.*
 Dec. 1926. Callender, Mrs. C. A., 31 *Inverleith Terrace, Edinburgh.*
 Feb. 1910. Galletly, Mrs. Sarah H., 32 *Mansionhouse Road, Edinburgh.*
 April 1902. Grieve, Mrs. Symington, 11 *Lauder Road, Edinburgh.*
 Nov. 1926. Smith, Mrs., *Inverleith House, Edinburgh.*

CORRESPONDING MEMBERS.

- Dec. 1905. Cockayne, L., Ph.D., F.R.S., F.L.S., *Nguio, Wellington, New Zealand.*
 Dec. 1905. Constantin, Dr. J., *Professeur au Muséum d'Histoire Naturelle, Paris.*
 Mar. 1895. Elfving, Dr. Fredrik, *Professor-Emeritus of Botany, Kopmansgatan 10, Helsingfors, Finland.*
 Dec. 1905. Gravis, Auguste, *Professor at the University, and Director of the Botanic Garden, Liège, Belgium.*
 Dec. 1905. Mattiolo, Professor O., *R. Istituto Botanico, Torino (120), Italy.*
 Dec. 1905. Miyabe, Dr. Kingo, *Professor of Botany, Hokkaido Imperial University, and Director of the Botanic Garden, Sapporo, Hokkaido, Japan.*
 June 1902. Miyoshi, Manabu, *Professor of Botany, Imperial University, Tokio, Japan.*
 June 1902. Raunkiaer, Professor Christen, *Botanic Museum, Copenhagen, Denmark.*
 Dec. 1905. Rodway, Leonard, *Government Botanist of Tasmania, Hobart, Tasmania.*
 Dec. 1905. Schröter, Dr. Carl, *Professor of Botany and Director of the Botanical Museum, Zürich, Switzerland.*

THE SOCIETY EXCHANGES PUBLICATIONS WITH—

EUROPE.

GREAT BRITAIN AND IRELAND.

- Aberystwyth*, . . . Welsh Plant Breeding Station.
Belfast, Natural History and Philosophical Society.
Berwick, Berwickshire Naturalists' Club.
Bristol, Bristol Naturalists' Society.
Cambridge, . . . Philosophical Society.
Cardiff, Naturalists' Society.
Dublin, Royal Dublin Society.
Dumfries, Dumfriesshire and Galloway Natural History Society.
East Malling, . . East Malling Research Station.
Edinburgh, . . . Edinburgh Geological Society.
 Royal Scottish Forestry Society.
 Royal Scottish Geographical Society.
 Royal Scottish Society of Arts.
 Royal Society of Edinburgh.
 University of Edinburgh.
Glasgow, Glasgow and Andersonian Natural History Society.
 Royal Philosophical Society.
 University of Glasgow.
Hull, Yorkshire Naturalists' Union.
Leeds, University of Leeds.
Liverpool, . . . Hartley Botanical Laboratories.
London, Editor of *Gardeners' Chronicle*.
 Editor of *Nature*.
 Linnean Society.
 Ministry of Agriculture.
 Quekett Microscopical Club.
 Royal Botanic Gardens, Kew.
 Royal Horticultural Society.
 Royal Microscopical Society.
 Royal Society.
 Science Library, South Kensington.
Manchester, . . Manchester Literary and Philosophical Society.
Millport, Scottish Marine Biological Association.
Newcastle-
upon-Tyne, . . Natural History Society of Northumberland, Durham,
 and Newcastle-on-Tyne.
 University of Durham Philosophical Society.
Norwich, Norfolk and Norwich Naturalists' Society.
Perth, Perthshire Society of Natural Science.
Plymouth, . . . Plymouth Institution.
Stratford, . . . Essex Field Club.
Watford, Hertfordshire Natural History Society and Field Club.

AUSTRIA.

- Graz*, Naturwiss. Verein für Steiermark.
Vienna, Zoologisch-Botanische Gesellschaft.

BELGIUM.

- Brussels*, . . . Académie Royale de Belgique.
 Institut Botanique Léo Errera.
 Société Royale de Botanique de Belgique.

BULGARIA.

- Sofia*, Société Botanique de Bulgarie.

CZECHOSLOVAKIA.

- Brno*, Faculty of Science, Masaryk University.
Prague, Czechoslovakian Botanical Society.
 The Botanical Institute, Charles University.

DENMARK.

- Copenhagen*, . . Botanisk Haves Bibliothek.
 Dansk Botanisk Forening.
Disko, Greenland, . Den Danske Arktiske Station.
Lyngby, Statens plantepatologiske Forsøg.

FINLAND.

- Helsingfors*, . . Societas pro Fauna et Flora Fennica.
 Societas Zoolog-Botanica Fennica Vanamo.
 Society of Forestry in Finland.

FRANCE.

- Amiens*, Société Linnéenne du Nord de la France.
Brest, Société Botanique et Entomologique de Gers.
Cherbourg, . . . Société Nationale des Sciences Naturelles.
Lyons, Société Linnéenne de Lyon (Section Botanique).
Marseille, . . . Faculté des Sciences de Marseille.
Paris, Société Botanique de France.
Toulouse, . . . Société d'Histoire naturelle.

GERMANY.

- Berlin*, Botanischer Verein der Provinz Brandenburg.
Bonn, Naturhist. Verein d. Preussischen Rheinlande, etc.
Breslau, Schlesische Gesellschaft f. Vaterländ Kultur.
Frankfurt-a-M., . Senckenbergische Bibliothek.
Gießen, Oberhessische Gesellschaft für Natur- und Heil-Kunde.
Kiel, Naturwissenschaftlicher Verein für Schleswig-Holstein.

HOLLAND.

- Amsterdam*, . . Botanical Society of Holland.
 Koloniaal Instituut.
 Koninklijke Akademie van Wetenschappen.
Haarlem, . . . Musée Teyler.
Leiden, Rijks Herbarium.
Wageningen, . . State Agricultural Library.

HUNGARY.

- Budapest*, . . . Hungarian Association of Natural Sciences.

ITALY.

- Florence*, . . . Societa Botanica Italiana.
Rome, International Institute of Agriculture.
 Regio Istituto Botanico.
Palermo, Sicily, . Editor of *Malpighia*.

LITHUANIA.

- Kaunas*, Mat-gamtos fakulteto Darbai Universitetas.

LUXEMBOURG.

Luxembourg, . . . Société Botanique du Grand-duché de Luxembourg.

NORWAY.

Oslo, Botanic Garden.

Tromsø, Tromsø Museum.

POLAND.

Krakow, Laboratorium Botanicum Janczewskianum.

Polish Academy of Science.

Lwów, Société Polonaise des Naturalistes "Kopernik."

Warsaw, Société Botanique de Pologne.

●

PORTUGAL.

Coimbra, Instituto Botanico, Universidade.

Lisbon, Academia das Sciencias.

RUSSIA.

Kiew, Société des Naturalistes de Kiew.

Leningrad, Academy of Sciences.

Botanic Garden.

Moscow, Société des Naturalistes de Moscou.

Tashkent, First Central Asiatic University.

Tiflis, Botanic Garden.

SWEDEN.

Gothenburg, Goteborgs Botaniska Trädgård.

Lund, Universitas Lundensis.

Stockholm, Kungl. Svenska Vetenskaps Akademien.

Svenska Botaniska Föreningen.

Uppsala, Kungl. Vetenskaps Societeten.

SWITZERLAND.

Berne, Naturforschende Gesellschaft.

Geneva, Conservatoire et Jardin Botaniques.

Institut Botanique, Herbar Boissier

Zurich, Naturforschende Gesellschaft.

Schweizerische botanische Gesellschaft

AFRICA.

Cape Town, South African Museum

ASIA.

Calcutta, Royal Botanic Garden.

Pusa, Agricultural Research Station.

Peradeniya, Royal Botanic Gardens.

Singapore, Botanic Gardens.

Manila, Bureau of Science.

Buitenzorg, Departement van Landbouw, Nijverheid en Handel.

Formosa, Department of Forestry.

Kurashiki, Ohara Institute for Agricultural Research.

Sapporo, Sapporo Natural History Society.

Sendai, Biological Institute, Tohoku Imperial University.

Tokio, College of Agriculture, Imperial University.

AUSTRALASIA.

- Brisbane*, . . . Department of Agriculture.
 Royal Society of Queensland.
Hobart, . . . Royal Society of Tasmania.
Launceston, . . . Department of Agriculture, Tasmania.
Melbourne, . . . Botanical Department, University of Melbourne.
 National Herbarium.
 Royal Society of Victoria.
Sydney, . . . Fisher Library, Sydney University.
 Linnean Society of New South Wales.
 Royal Society of New South Wales.
Wellington, . . . New Zealand Institute

CANADA.

- Halifax*, . . . Nova Scotian Institute of Natural Science.
Montreal, . . . M'Gill University.
Ottawa, . . . Canadian Forestry Association.
 Central Experiment Farms.
 Department of Agriculture.
 Department of the Interior, Forestry Branch.
 Geological Survey of Canada.
Toronto, . . . Royal Canadian Institute.

SOUTH AMERICA.

- Bogota*, . . . Ministry of Public Works.
Buenos Aires, . . . Museo Nacional de Historia Natural, Seccion Botanica.
La Plata, . . . Museo de La Plata.
Monte Video, . . . Museo Nacional de Monte Video.
Rio de Janeiro, . . . Botanic Garden.
 Museu Nacional.
San Paulo, . . . Museu Paulista (Secção de Botanica).

UNITED STATES.

- Ames, Iowa*, . . . Iowa State College.
Ann Arbor, Mich., . . . University of Michigan.
Berkeley, Cal., . . . University of California.
Boston, Mass., . . . Massachusetts Horticultural Society.
 Society of Natural History.
Brooklyn, N. Y., . . . Brooklyn Botanic Garden.
Cambridge, Mass., . . . Gray Herbarium, Harvard University.
Cincinnati, O., . . . Lloyd Botanical Library.
 Society of Natural History.
Colorado }
Springs, Col., } Colorado College.
Columbia, Mo., . . . University of Missouri.
Columbus, O., . . . Ohio State University.
Geneva, N. Y., . . . Agricultural Experiment Station.
Indianapolis, Ind., . . . Indiana Academy of Sciences.
Ithaca, N. Y., . . . New York State College of Agriculture.
Jamaica Plain, Mass., } Arnold Arboretum.
La Fayette, Ind., . . . Purdue University Agricultural Experiment Station.
Laurence, Kan., . . . Academy of Science.
Madison, Wis., . . . Agricultural Experiment Station.
 Wisconsin Academy of Sciences.
Manhattan, Kan., . . . State Agricultural College.

- Milwaukee, Wis.*, . Public Museum.
Minneapolis,
 Minn., } Botanical Department, University of Minnesota.
New Haven, Conn., Academy of Arts and Sciences.
New York, N. Y., Academy of Sciences.
 Torrey Botanical Club.
Philadelphia, Pa., Academy of Natural Sciences.
 American Philosophical Society.
 University of Pennsylvania.
Rochester, N. Y., . Rochester Academy of Sciences.
St. Louis, Mo., . Missouri Botanical Garden.
San Francisco, } California Academy of Sciences.
 Cal., }
Urbana, Ill., . University of Illinois.
Washington, D. C., National Academy of Sciences.
 Smithsonian Institution.
 United States Department of Agriculture ; Forest Ser-
 vice ; National Museum ; Office of Experiment
 Stations.
Woods Hole, Mass., Marine Biological Laboratory.

WEST INDIES.

- Jamaica,* . Department of Agriculture.
Trinidad, . . . Royal Botanic Garden.

INDEX.

- Acalypha*, Vegetative Propagation of, 282.
 Adam, Robert Moyes, iii, x, xx, xxix, 187, 246, 250, 326.
 Aiken, Rev. J. J. Marshall Lang. 49.
 Alcock, Mrs. N. L., vii, xxi, 13, 332, 338.
 Algae from West Inverness-shire, iii.
 Alteration of Laws, iv, v.
 Andes, Plant Collecting in, xxviii.
 Anthers, Structure of certain Poricidal, 104.
Aplanobacter Kathayi, xiv.
Arenaria peploides, 157.
Ascochyta piniperda, xxii.
 Barker, Miss, xiii.
 Baron, C. Marion, 70, 127.
 Beijerinck, Professor, xxviii.
 Bennett, Arthur, iv, 1.
 ———— Obituary of, 180.
 Bhutan, Flora of, xxvi.
 Bolting in Root Crops, vii.
Botrytis elliptica, 63.
 Bovell, Marjorie L. R., 46.
 Boyd, Lucy, 218, 286.
 Bracken Disease, xv.
 Bracken, Effect of Cutting, 3.
 Bracken, Spread of, by Spores, 209.
 Broccoli, Vegetative Propagation of, 216.
 Brown, A. B., xiv.
 Buchanan, E. M., ii.
 Buchan-Hepburn, Sir Archibald, xv.
 Burma, Types of Forest and People in, ii.
 Cadman, Miss Elsie, v, xxviii.
 Caithness Plants, 1.
Cassia australis, Anthers in, 112.
Ceratostomella, Heterothallism in, xxix.
 Circumnutation of *Helianthus tuberosus*, xxiv.
 ———— of *Melaleuca integrifolia*, 46.
 Clark, James, xiv.
 Clarke, Robert R., xv.
 Clover, Seed-borne Disease of, 13.
Cnicus heterophyllus var. *laciniosus*, iv.
 Cocksfoot, Disease of, xiv.
Codium adhaerens, iii.
 Coldstream, Wm., xiv.
Coleus, Root Formation in, 53.
 Comber, Harold F., xxviii.
 Cooper, R. E., xxvi.
 Cork Formation in *Rhododendron*, 127.
Costus spectosus, Seedling of, 221.
 Crystals in *Mesembryanthemum*, 43.
 Currie, James, xxvi.
Cuscuta reflexa, xxii.
 Davey, V. E. M., vii, xiii.
Didymum difforme, v.
 ———— *nigripes*, v, xxviii.
Dioscorea, Vegetative Propagation of, 282.
Diphyscium foliosum, xiv.
 Douglas Fir, Leaf-fall in, xiv.
 Drabble, Eric, 190.
 Duckworth, Sir Dyce, vi.
 Dutch Elm Disease, v.
 Evans, W. Edgar, xiv.
 Evolution in the Monocotyledonous Seedling, 286.
 Fasciated Tulips, xxiii.
 Fenton, E. Wyllie, xiv.
 Ferguson, Jas. A., viii.
 Floating Power of Seaweed, xxvi, 72, 78, 89.
 Flora of Bhutan, xxvi.
 Flora of Yunnan, vi.
 Flower Colours as Natural Indicators, 230.
 Foister, C. E., 244, 257, 338.
 Forrest, George, vi, vii, xviii.
 Foxglove, Peloria in, iv.
 Fungous Diseases in Scotland, 338.
 Galloway Roses, 239.
 Gilliland, H. B., 284.
Glaur maritima, 304.
 Glen Affric, 187.
 Gourlay, W. Balfour, 131.
 Graham, R. J. D., xviii, 19, 67, 70, 212, 216, 282.
 Grampian Electricity Supply Bill, xx.
 Grass Embryo, 286.
 Grasses, Recognition of, by Vegetative Characters, 206.
 Grasslands, Scottish, xix.
 Gregor, James W., vi, xxi.
 Gregor, Mrs. M. J. F., xxix.
 Grieve, Symington, xxi, xxvi, 72, 78, 89.

Gymnosperms, Vegetative Propagation of, 67.
 Hahn, Glenn Gardner, 137.
 Heaths, Leaf Anatomy of British, 198.
Helianthus tuberosus, Circumnutation of, xxiv.
 Herring, Miss, xxix.
 Heterothallism in *Ceratostomella*, xxix.
 Hill, J. Rutherford, iv.
 Holmes, E. M., xxvi.
 Im Thurn, Sir Everard, xxiii.
 Injection Experiments on Trees, 19.
 Ivy-leaved Toad-Flax in Scotland, 123.
 Johnston, Col. H. H., vii.
 Johnstone, J. T., xxx.
 Jolly, M. I., xxxi.
Kalanchoe verticillata, Vegetative Propagation of, 70.
 Kean, Chrissy I., 37, 43, 164.
 Laws, Alteration of, iv, v.
 Leaf Anatomy of British Heaths, 198.
 Leaf-fall in Douglas Fir, xiv.
 Leeks, White Tip Disease of, 257.
 Lennox, Dr., xxix.
 Light Receptors in *Mesembryanthemum*, 43.
 Lily Disease, 59.
Linaria Cymbalaria in Scotland, 123.
Linnaea borealis, vii.
 M'Intosh, William Carmichael, Obituary of, 351.
 MacLachlan, C. M., 104.
 McNicoll, Isabella S., 147.
 Massie, W. H., x.
 Matthews, J. R., xiv, xviii, 104, 239.
Melaleuca integrifolia, Circumnutation record of, 46.
Mesembryanthemum, Artificial Crystals in, 43.
 — Light Receptors in, 37.
 — Seedling Anatomy in, 164.
 Millar, Robert Cockburn, Obituary of, 178.
 Miller, Elizabeth W., 21.
 Mistletoe on Lime, x.
 Moir, Margaret A., xxiv, 304.
 Monocotyledonous Seedling, Evolution in, 286.
 Monocotylous Seedlings, Development and Anatomy of, 218.
 Morphology of the Grass Embryo, 286.
 Muirhead, George, vi.
Myrica Gale, Parasitic Fungus on, 244.
 New Honorary British Fellow —
 Lang, Prof. William Henry, xxviii.
 New Fellows —
 Allardyce, G. L., xxviii.
 Brodie, John, vi.
 Brown, Alexander B., xix.
 Burrell, Sir Wm., v.
 Clarke, Robert R., xii.
 Cowan, J. M., xxvi.
 Cowan, Robert Craig, xv.
 Cowie, Mrs. Harold, xxviii.
 Dickson, Miss A. W., xxviii.
 Dobson, Miss Margaret Gairns, iii.
 Egerton, Maj.-Gen. Granville, xxviii.
 Fenton, E. Wyllie, iv.

New Fellows—continued.
 Foister, Charles Edward, x.
 Forrest, Mrs. George, vi.
 Fortune, T. A. S., xxviii.
 Heddle, R. G., xx.
 Lang, J. M. S., iii.
 Latham, H. A., xxx.
 M'Ginn, Charles D'Arcy, vi.
 Martin, Mrs. Agnes D., x.
 Martin Miss Mary S., v.
 Muirhead, Charles, xxviii.
 Murray, Miss F. B., xix.
 Murray, Robert, xxvi.
 Owen, John Lewis, vi.
 Reid, Mrs. Murray, ii.
 Steel, William B., xxvi.
 Sutherland, Mrs. Kate, vii.
 Terras, Mrs. Kate R., xviii.
 Thomson, Miss Norah M'Nab, x.
 Torbock, H. C., xxviii.
 Traill, William Henry, vi.
 Watt, Mrs. Menie, xxiii.
 Whyte, James H., xxviii.
 New Associate—
 Forrest, George, ii.
 Obituary Notices—
 Bennett, Arthur, 180.
 M'Intosh, William Carmichael, 351.
 Millar, Robert Cockburn, 178.
 Paul, David, 183.
 Smith, William Gardner, 175.
Orchna serrulata, Anthers in, 116.
 Orkney, Flora of, vii.
 Orr, M. Y., xxx.
 Ostenfeld, Professor, xxviii.
Ovularia destructiva on *Myrica Gale*, 244.
 Pansies, Scottish, 190.
Paris polyphylla, Seedling of, 216.
 Park, James, 320.
 Paul, David, Obituary of, 183.
 Peloria in Foxglove, iv.
Phleum pratense × *P. alpinum*, vi.
Phytophthora Porri, 257, 277.
 Plant Collecting in the Andes, xxviii.
 Plant Communities of Yunnan, xii.
Plantago maritima, xxi, 313.
 Plum Scab, vii.
 Poplar, Canadian, xvi.
 Pratt, Alexander, 157.
Primula, Distribution of, vii.
Primula Reidii, vii.
Pteris aquilina, 3.
 Ranunculaceous Seedlings, Schizocotly in, 21.
 Red Currant, a Resistant, 137.
Rhabdocline Pseudotsugae, xiv.
Rhododendron, Cork Formation in, 127.
 Richardson, A. D., xxi.
 Root Formation in *Coleus*, 53.
 Roses, Galloway, 239.
Ruscus aculeatus, Anomalous Stem Structure in, 284.
Salsola Kali, 147.
 Salt-Marsh Plants, Notes on, 304, 313, 320.
 Schizocotly in Ranunculaceous Seedlings, 21.

- Scilly, Isles of, xiv.
 Scottish Alpine Botanical Club Excursion, 1927, 49.
 ———— 1928, 246.
 ———— 1929, 250.
 ———— 1930, 326.
 Scottish Grasslands, xix.
 Scottish Pansies, 190.
 Sea Plantain, Growth Forms within, xxi.
 Seaweed, Floating Power of, xxi, 72, 78, 89.
 Seed-borne Diseases, 332.
 Seedling Anatomy in *Mesembryanthemum*, 164.
 Shetland, Flora of, vii.
 Smith, E. Philip, xxi, 53, 230.
 Smith, Margaret H., 198.
 Smith, William Gardner, 3.
 — - - Obituary of, 175.
 Smith, W. Wright, vii.
 South Africa, British Association in, xvi.
 Spruce Cones, Disease of, xxii.
Stenoglottis longifolia, Vegetative Propagation of, 282.
 Stevenson, Miss J. J., xxxi.
 Stewart, David F., 313.
 Stewart, L. B., iv, xii, 19, 67, 70, 212, 216, 282.
 Stewart, William, xviii.
 Stomatal Movement, xxxi.
 Strand Plants, 117, 157.
 Taylor, George, viii.
Tetraplodon mnoides, xiv.
Tetralthea pilosa, Anthers in, 109.
 Thornton's Pictures of Flowers, xxx.
Tibouchina semidecandra, Anthers in, 105.
 Timothy Grass, vi.
 Trees, Injection Experiments on, 19.
Trifolium repens, Seed-borne Disease of, 13.
Triglochin maritimum, 320.
 Tulips, Fasciated, xxiii.
Vaccinium intermedium, 131.
 Vegetative Propagation of *Acalypha*, 282.
 ——— of Broccoli, 216.
 ——— of *Dioscorea*, 282.
 ——— of Gymnosperms, 67.
 — - - of *Kalanchoe verticillata*, 70.
 ——— of *Stenoglottis longifolia*, 282.
 Vita Glass, Experiments with, 212.
 Watt, Hugh Boyd, 123.
 Weaver Bird's Nests, xxvi.
 White Tip Disease of Leeks, 257.
 Whyte, J. H., 206, 209.
 Wilson, E. H., xxvi.
 Wilson, Malcolm, xiv, xxii.
 Wilson, Miss M. J. F., v.
 Wright, James, 59.
 Yunnan, Flora of, vi, xii.
 Yunnan, Peoples and Customs of, xviii.
Zamioculcas Loddigesii, iv.

I. A. B. I. 75-4

IMPERIAL AGRICULTURAL RESEARCH
INSTITUTE LIBRARY
NEW DELHI.

[illegible]